DOT/FAA/AR-00/12

Office of Aviation Research
Washington, D.C. 20591

Aircraft Materials Fire Test Handbook

April 2000

Final Report

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AR-00/12		

4. Title and Subtitle	5. Report Date
AIRCRAFT MATERIALS FIRE TEST HANDBOOK	April 2000
	6. Performing Organization Code
7. Author(s) Compiled by April Horner	8. Performing Organization Report No.
9. Performing Organization Name and Address Federal Aviation Administration Fire Safety Section, AAR-422 William J. Hughes Technical Center Atlantic City International Airport New Jersey 08405	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Office of Aviation Research Washington, DC 20591	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code ANM-100

15. Supplementary Notes

This handbook provides information supplemental to any presently available applicable Advisory Circulars. The FAA William J. Hughes Technical Center Monitor was Richard Hill.

16. Abstract

The purpose of the Aircraft Materials Fire Test Handbook is to describe all FAA-required fire test methods for aircraft materials in a consistent and detailed format. The handbook provides information to enable the user to assemble and properly use the test methods. Moreover, to broaden the utility of the handbook, the appendices contain the following information: FAA fire safety regulations, FAA approval process, aircraft materials, regulatory methodology used by other countries, aircraft industry internal test methods and guidelines, laboratories actively using fire test methods, and commercial manufacturers of fire test equipment.

17. Key Words	18. Distribution Statement
Fire Safety, Aircraft interior materials, Flammability	This document is available to the public through the National Technical Information Service (NTIS) Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	234	

Form DOT F1700.7 (8-72) Reproduction of completed page authorized

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LIST OF ACRONYMS

A	Ampere(s)
AC	Advisory Circular
AC	Alternating Current
ACD	Aircraft Certification Directorate/Division
ACO	Aircraft Certification Office
AD	Airworthiness Directive
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ATC	Air Traffic Control
AWG	American Wire Gauge
BAA	Bilateral Airworthiness Agreement
BCAR	British Civil Airworthiness Requirement
Btu	British Thermal Unit
C	Centigrade
CAA	Civil Aeronautics Administration
CAB	Civil Aeronautics Board
CAMI	Civil Aeromedical Institute
CAR	Civil Air Regulation
CC	Constant Capacity
CFR	Code of Federal Regulations
CL	Center Line
cm	Centimeter(s)
DC	Direct Current
DER	Designated Engineering Representative
DMIR	Designated Manufacturing Inspection Representative
DOT	Department of Transportation
D_s	Specific Optical Density
F	Fahrenheit
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
$Fe(CO)_5$	Iron pentcarbonyl

FPM	Feet per Minute
FR	Fire-Retarded
FR	Flame Retardant
FSS	Flight Standards Service
FSSR	Flight Standards Service Release
g	Gram(s)
GENOT	General Notice
H_2O	Water
Hg	Mercury
HP	Horsepower
Hz	Hertz
ICAO	International Civil Aviation Organization
ID	Inside Diameter
JAR	Joint Airworthiness Regulation
K	Kelvin
kPa	Kilo Pascal(s)
Kv	Kilovolt(s)
kVA	Kilovolt Ampere(s)
kW	Kilowatt(s)
L	Liter
m	Meter
MIDO	Manufacturing Inspection District Office
mil	Milliliter
mm	Millimeter(s)
MPa	Mega Pascal(s)
MPS	Meters per Second
mV	Millivolt(s)
NBS	National Bureau of Standards
NF	National Fine
NIST	National Institute of Standards and Technology
NPRM	Notice of Proposed Rulemaking
NPT	Normal Pressure and Temperature
OD	Outside Diameter
OEM	Original Equipment Manufacturer
PATCO	Professional Air Traffic Controllers Organization
PI	Principal Investigator
PMA	Part Manufacturer Approval
psi	Pounds per Square Inch
psig	Pounds per Square Inch—Gauge
PTFE	Polyethylenetetrafluoroethylene
PVF	Polyvinyl Fluoride
S	Second
SAE	Society of Automotive Engineers
SRR	Safety Regulation Release

STC	Supplemental Type Certificate
STP	Standard Temperature and Pressure
TC	Type Certificate
THD	Thread
TSO	Technical Standard Order
UV	Ultraviolet
V	Volt
W	Watt(s)

EXECUTIVE SUMMARY

In order to assure prescribed levels of fire safety in civil aircraft, the Federal Aviation Administration (FAA) requires that a variety of fire test methods be used to demonstrate that aircraft materials meet specified performance criteria when exposed to heat or flame. In principle, the specific test method required serves as a surrogate for the fire environment to which a given material could potentially be exposed, and the test criteria relate to the performance of the material in this fire environment. This handbook provides information supplemental to any presently available applicable Advisory Circulars.

While a number of fire test requirements are of recent vintage, others have origins in research and development efforts completed many years ago. Because of a span of time during which the various fire test requirements were developed, there is an inevitable wide variation in the accessibility of primary technical documents, in currency of test equipment details, and in style and clarity of technical content.

The purpose of the *Aircraft Materials Fire Test Handbook* is to describe all FAA-required fire test methods for aircraft materials in a consistent and detailed format. The handbook provides information to enable the user to assemble and properly use the test methods. Moreover, to broaden the utility of the handbook, the appendices contain the following information: FAA fire safety regulations, FAA approval process, aircraft materials, regulatory methodology used by other countries, aircraft industry internal test methods and guidelines, laboratories actively using fire test methods, and commercial manufacturers of fire test equipment.

Chapter 1
Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials

1.1 Scope

This test method is intended for use in determining the resistance of materials to flame when tested according to the 60-second and 12-second Vertical Bunsen Burner Tests specified in Federal Aviation Regulation (FAR) 25.853 and FAR 25.855.

1.2 Definitions

1.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. It can be either 60 seconds or 12 seconds for this test.

1.2.2 Flame Time

Flame time is the time in seconds that the specimen continues to flame after the burner flame is removed from beneath the specimen. Surface burning that results in a glow but not in a flame is not included.

1.2.3 Drip Flame Time

Drip flame time is the time in seconds that any flaming material continues to flame after falling from the specimen to the floor of the chamber. If no material falls from the specimen, the drip flame time is reported to be 0 seconds, and the notation "No Drip" is also reported. If there is more than one drip, the drip flame time reported is that of the longest flaming drip. If succeeding flaming drips reignite earlier drips that flamed, the drip flame time reported is the total of all flaming drips.

1.2.4 Burn Length

Burn length is the distance from the original specimen edge to the farthest evidence of damage to the test specimen due to that area's combustion including areas of partial consumption, charring, or embrittlement but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat.

1.3 Test Apparatus

1.3.1 Test Cabinet

Tests will be conducted in a draft-free cabinet fabricated in accordance with figures 1-1 to 1-3 or other equivalent enclosures acceptable to the Federal Aviation Administration (FAA). It is suggested that the cabinet be located inside an exhaust hood to facilitate clearing the cabinet of smoke after each test. Stainless steel or other corrosion-resistant metal 0.04 inch (1 mm) thick will be used for the bottom surface of the chamber.

1.3.2 Specimen Holder

The specimen holder will be fabricated of corrosion-resistant metal in accordance with figure 1-3 or the equivalent. The holder will be able to accommodate specimens up to 1 inch (25 mm) thick.

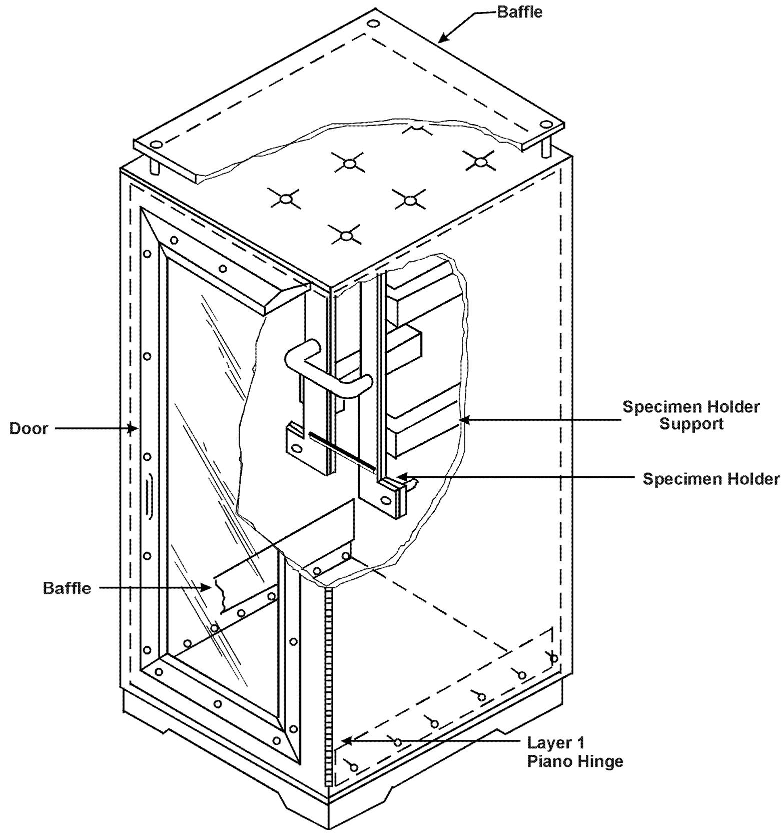

Figure 1-1. Sketch of Vertical Bunsen Burner Test Cabinet

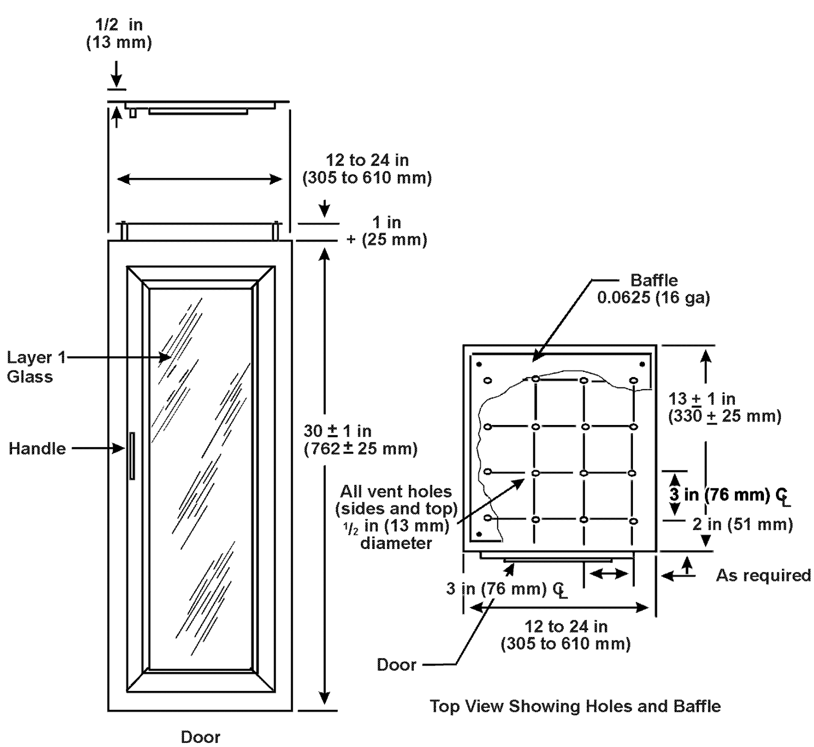

Figure 1-2. Front and Top View of Vertical Bunsen Burner Test Cabinet

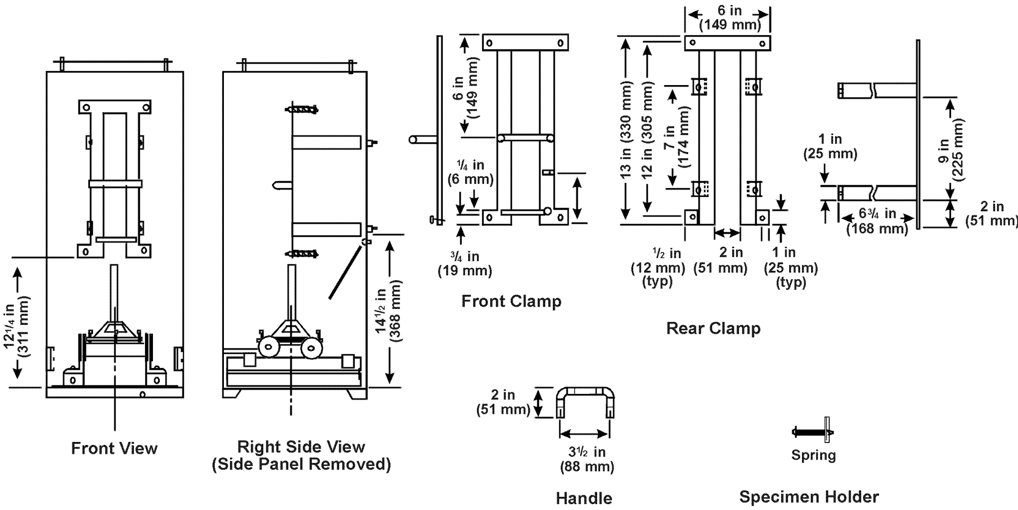

Figure 1-3. Vertical Bunsen Burner Test Specimen Holder

1.3.3 Burner

The burner will be a Bunsen or Tirrill type, have a 3/8-inch (10-mm) inside diameter barrel, and be equipped with a needle valve located at the bottom of the burner barrel to adjust the gas flow rate and, thereby, adjust the flame height. There will be a means provided to move the burner into and out of test position when the cabinet door is closed.

1.3.3.1 Burner Fuel

Methane gas (99 percent minimum purity) or other burner fuel acceptable to the FAA will be used. Methane is the preferred fuel. It can be used without adding air through the aspirating holes at the bottom of the burner barrel; e.g., a pure diffusion flame may be used.

1.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure 1-4. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2 1/2 ± 1/4 psi (17 ± 2 kPa) at the burner inlet will be installed between the gas supply and the burner.

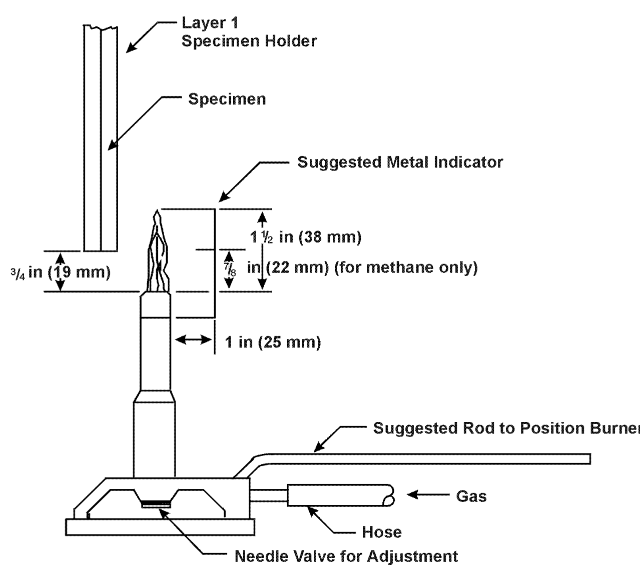

Figure 1-4. Burner Plumbing and Burner Flame Height Indicator

1.3.3.3 Flame Height Indicator

A flame height indicator may be used to aid in setting the height of the flame. A suitable indicator has a prong extending 1.5 inches (38 mm) above the top of the burner barrel, is attached to the burner barrel, and spaced 1 inch (25 mm) from the burner barrel, as shown in figure 1-4. If using methane as the burner fuel, it is desirable to have two prongs for measuring the flame height, one prong to indicate the height of the inner cone of the flame and one prong to indicate the height of the tip of the flame. For methane, it has been determined that when the height of the inner cone is 7/8 inch (22 mm) and the tip of the flame is 1.5 inches (38 mm) long, the proper flame profile is achieved.

1.3.4 Timer

A stopwatch or other device, calibrated to the nearest 0.1 second, will be used to measure the time of application of the burner flame, the flame time, and the drip flame time.

1.3.5 Ruler

A ruler or scale graduated to the nearest 0.1 inch (2.5 mm) will be provided to measure the burn length.

1.4 Test Specimens

1.4.1 Specimen Selection

Specimens tested will be either cut from a fabricated part as installed in the aircraft or cut from a section simulating a fabricated part, e.g., cut from a flat sheet of material or from a model of the fabricated part. The specimen may be cut from any location in the fabricated part. However, the edge to which the burner is applied must not consist of the finished or protected edge of the specimen. Fabricated units, such as sandwich panels, will not be separated into individual component layers for testing.

1.4.1.1 For parts that may have different flammability characteristics in different directions (e.g., textiles), separate sets of specimens, cut from each direction showing the greatest difference (e.g., warp and fill), will be provided and tested.

1.4.2 Specimen Number

Each separate set of specimens prepared for testing will consist of at least three specimens (multiple places).

1.4.3 Specimen Size

The specimen will be a rectangle at least 3 by 12 inches (75 by 305 mm), unless the actual size used in the aircraft is smaller.

1.4.4 Specimen Thickness

The specimen thickness will be the same as that of the part qualified for use in the airplane, with the following exceptions:

1.4.4.1 If the part construction is used in several thicknesses, the minimum thickness will be tested.

1.4.4.2 Foam parts that are thicker than 1/2 inch (13 mm), such as seat cushions, will be tested in 1/2-inch (13-mm) thicknesses.

1.4.4.3 Parts that are smaller than the size of a specimen and cannot have specimens cut from them may be tested using a flat sheet of the material used to fabricate the part in the actual thickness used in the aircraft.

1.5 Conditioning

Specimens will be conditioned at 70° ± 5°F (21° ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum. Remove only one specimen at a time from the conditioning environment immediately before testing.

1.6 Procedure

1.6.1 Burner Adjustment

1.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.

1.6.1.2 Open the stopcock in the gas line fully and light the burner.

1.6.1.3 Adjust the needle valve on the burner to achieve the proper 1.5-inch (38-mm) flame height, in accordance with section 1.3.3.3.

1.6.2 Test Procedure

1.6.2.1 Place the burner at least 3 inches (76 mm) from where the specimen will be located during the test.

1.6.2.2 Insert the specimen with its lower edge 3/4 inch (19 mm) above the level of the top of the burner.

1.6.2.3 Close the cabinet door, and keep it closed during the test.

1.6.2.4 Start the timer immediately upon positioning the burner. Position the burner so that the flame impinges on the midpoint of the lower edge of the front face of the test specimen. This flame position should be used for all specimen thicknesses (see figure 1-5).

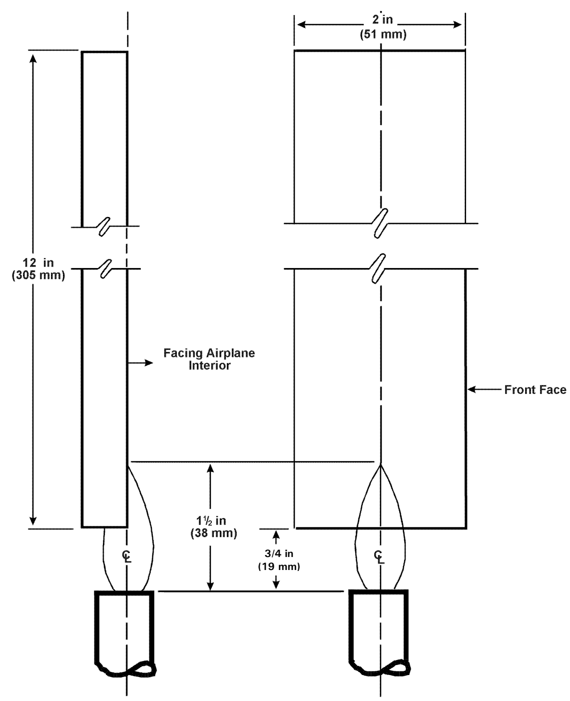

Figure 1-5. Flame Position on Vertical Specimens

1.6.2.5 Apply the flame for 12 seconds or 60 seconds, as appropriate, and then withdraw it by moving the burner at least 3 inches (76 mm) from the specimen or by turning the gas off.

1.6.2.6 If flaming material falls from the test specimen, determine the drip flame time for the specimen.

1.6.2.7 Determine the flame time for the specimen.

1.6.2.8 After all flaming ceases, open the cabinet door slowly to clear the test cabinet of fumes and smoke. The exhaust fan may be turned on to facilitate clearing smoke and fumes.

1.6.2.9 Remove the specimen and determine the burn length. To aid in determining the burn length, a dry soft cloth or tissue, or a soft cloth or tissue dampened with a moderate solvent, such as methyl, ethyl, or isopropyl alcohol (which does not dissolve or attack the specimen material), may be used to remove soot and stain particles from tested specimens.

1.6.2.10 Remove any material from the bottom of the cabinet that fell from the specimen. If necessary, clean the test cabinet window and/or back face mirror prior to testing the next specimen.

1.7 Report

1.7.1 Material Identification

Fully identify the material tested, including thickness. Also, include the specimen length if a 12-inch specimen is not available.

1.7.2 Test Results

1.7.2.1 Ignition Time

Report whether the ignition time was 12 seconds or 60 seconds.

1.7.2.2 Flame Time

Report the flame time for each specimen tested. Determine and record the average value for flame time (see section 1.2.2).

1.7.2.3 Drip Flame Time

Report the drip flame time for each specimen tested. Determine and record the average value for the drip flame time (see section 1.2.3). For specimens that have no drips, record "0" for the drip flame time and also record "No Drips."

1.7.2.4 Burn Length

Report the burn length to the nearest 0.1 inch for each specimen tested. Determine and record the average value for burn length.

1.8 Requirements

1.8.1 Flame Time

The average flame time for all of the specimens tested will not exceed 15 seconds for either the 12-second or the 60-second vertical test.

1.8.2 Drip Flame Time

The average drip extinguishing time for all of the specimens tested will not exceed 3 seconds for the 60-second vertical test or 5 seconds for the 12-second vertical test.

1.8.3 Burn Length

The average burn length for all of the specimens tested will not exceed 6 inches (152 mm) for the 60-second vertical test or 8 inches (203 mm) for the 12-second vertical test.

Chapter 1 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

1.2.1 Ignition time should start only after the flame has stabilized and is properly positioned under the test specimen.

1.2.4 This definition of burn length is a clarification of that used in FAR 25, Appendix F, Part I, viz.: "Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat source." The main point is that "damage to the test specimen due to flame impingement" is clarified by "damage to the test specimen due to that area's combustion" because it is a better description of the intent of the rule and is consistent with current test practices.

The burn length definition specified in FAR 25, Appendix F, applies to all materials listed in Part 25.853 and FAR 25.855. Since such a wide variety of materials require vertical Bunsen burner testing, areas that might obviously be included as burn length in some materials may not always be as well defined in others.

While burn lengths of materials used in modern aircraft interiors generally fall well below the 6-inch (60-second) or 8-inch (12-second) maximum limit, it is beneficial to develop criteria for those materials that occasionally approach the pass/fail limit.

For the most part, these materials may be divided into four general categories; they are polymeric materials (such as panels, partitions, transparencies, etc., which may be hybrid or single plastic material), textiles, carpeting, and foams.

The following methods have been suggested for determining burn length:

a. Polymeric Materials. In order to fix the boundary where the flame front was impinging on the specimen surface and damaging the specimen due to that area's combustion, i.e., below which combustion of the specimen occurred and above which it did not, it is necessary to observe the specimen continuously during the test. Flame impingement on the specimen may lead to outgassing due to thermal decomposition. As these gases burn, radiating heat may cause discoloration, sooting, staining, melting, etc., to areas above the flame front. This type of damage is not a result of thermal decomposition due to flaming and, therefore, would not be included in the burn length.

b. Textiles. Burn length may be determined by using weights as specified in Test Method 5903.1, "Flame Resistance of Cloth, Vertical" (12/28/87) as follows:

   After removing the specimen from the test cabinet, allow the specimen to cool and then measure the burn length. The burn length is the distance from the end of the specimen, which was exposed to the flame, to the top of the lengthwise tear made through the center of the charred area. Fold the specimen lengthwise and crease it by hand along a line through the highest peak of the charred area. Insert the hook into the specimen (or insert it into a hole, 1/4 inch (6 mm) in diameter or less) at one side of the charred area 1/4 inch (6 mm) in from the lower end. Attach a weight to the hook of sufficient size (that the weight and hook together equal the total tearing load required shown in table 1).

   Gently apply a tearing force to the specimen by grasping the corner of the cloth at the opposite edge of the char from the load and raising the specimen and weight clear of the supporting surface. Raise the specimen in one smooth continuous motion; do not jerk or pull the specimen forcefully upward. Mark the end of the tear on the edge of the specimen and take the char length measurement along the undamaged edge.

c. Carpeting. Tear the specimen with your hands. Use only enough force to tear the charred material. Stop when the fabric does not give way freely.

d. Polyurethane Foams. Polyurethane foams are cellular in nature and, therefore, have low thermal conductivity. Since high surface temperatures are generated on exposure to the burner flame, an almost instantaneous conversion to flammable gases results. This, in turn, produces rapid surface flame spread with complete consumption of the foam immediately above the ignition source. By definition, complete consumption of an area is part of the burn length and should be included.

Table 1-1. Loads for Determining Char Length

The specific load applicable to the weight of the test cloth should be as follows:			
Specified weight per square yard of cloth before any fire retardant treatment or coating		**The tearing weight for determining the charred length**	
Ounces per square yard	**g/m^2**	**Pounds**	**kg**
2.0 to 6.0	68 to 203	0.25	0.1
Over 6.0 to 15.0	Over 203 to 508	0.5	0.2
Over 15.0 to 23.0	Over 508 to 780	0.75	0.3
Over 23.0	Over 780	1.0	0.45

1.3.1 Suitable test cabinets of the type described are manufactured by the U.S. Testing Co., 1415 Park Ave., Hoboken, New Jersey 07030; Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, Illinois 60613; and The Govmark Organization, Inc., P.O. Box 807, Bellmore, New York 11710.

Draft free implies a condition of no air currents in a closed in space. One way of determining whether the cabinet is draft free is to place a smoldering and smoking material, such as a lighted cigarette, in the test cabinet, then closing the door and observing the behavior of the smoke for signs of drafts. A test cabinet other than one fabricated in accordance with figures 1-1 to 1-3 may be found to be acceptable after review by the FAA.

The entire inside back wall of the chamber may be painted flat black to facilitate viewing of the test specimen, and a mirror may be located on the inside back surface to facilitate observation of the hidden surfaces.

1.3.3 A suitable burner is available from Rascher & Betzold Inc., 5410 N. Damen Ave., Chicago, Illinois 60625, Catalog No. R3726A.

1.3.3.1 Gases such as natural gas and propane can be used as burner fuel. However, it should be required to show compliance with the 1550°F minimum flame temperature using a 24 American Wire Guage (AWG) thermocouple.

B-gas, which is the burner fuel specified in Federal Test Method Standard 5903, meets minimum temperature requirements and is still used in some laboratories. However, its use has resulted in problems and is not recommended. See note below for more details.

NOTE: B-gas, a mixture of 55 percent hydrogen, 18 percent carbon monoxide, 24 percent methane, and 3 percent ethane, has shown inconsistent burning characteristics in steel cylinders. A "spike" of varying intensity is produced. It has been postulated that the carbon monoxide in the gas may react with the iron in the steel cylinders to produce iron pentcarbonyl ($Fe(CO)_5$), which is volatile and may cause interference with the normal flame characteristics and may be the cause of the erratic behavior. Because of the inconsistent flame characteristics, B-gas, at least if supplied in steel cylinders, is not recommended. No data are presently available about the suitability of B-gas supplied in cylinders of other materials, such as aluminum.

A phenomenon that some labs have experienced is a sharp decrease in flame temperature after about three-fourths of the gas originally in the cylinder has been used. This has occurred primarily in labs that have single-stage regulators on their gas cylinders. Single-stage regulators differ from two-stage regulators in that control of the discharge pressure is not as accurate. Few designs should maintain constant or near constant discharge pressures over the full range of cylinder pressures. Therefore, it is necessary to make adjustments periodically to allow for decreasing inlet pressures. Even the slightest drop in pressure should affect the flow rate of gas through the burner orifice. This, in turn, should cause temperature variation. By using a two-stage regulator or adjusting pressure on a single-stage regulator, as the cylinder gets low, this problem can essentially be eliminated.

1.3.3.3 The tip of the methane flame is blue, transparent, and difficult to see. It is more easily seen if there is no light on the flame, as in a darkened room. The inner cone of the flame is, however, more visible and easily seen and can be used to monitor flame height. When the flame height (blue transparent tip) is set to 1.5 inches, the height of the inner cone has been found to vary slightly from burner to burner, but is generally about 7/8 inch. Therefore, if the inner cone height is used to monitor flame height, the inner cone height needs to be established for that burner.

1.4.1 Currently, the most commonly used specimens are thermal/acoustic insulation blankets consisting of fiberglass insulation with scrimmed film cover. Appendix F to FAR Part 25 states that materials must be tested either as a section cut from a fabricated part as installed in the airplane or as a specimen simulating a cut section. Therefore, it is by regulation mandated that the insulation blanket be tested as a finished product (insulation and film cover together). Appendix F also states that the edge to which the burner flame is applied must not consist of the finished or protected edge of the specimen, but must be representative of the actual cross-section of the material or part installed in the airplane. Therefore, a 3- by 12-inch section of the blanket for vertical testing should be cut from the interior and must not include an enclosed edge.

1.4.3 By regulation, there must be at least 2 inches of the specimen exposed; however, the text specifies a specimen cut 3 inches in width. This allows enough material to ensure that the specimen is securely held in the holder. From experience, it has been found that materials such as textiles and films are difficult to secure in the holder and, therefore, may be cut even greater than 3 inches in width. This allows the operator adequate material to pull or adjust so that the specimen does not buckle or fall out of the holder.

1.4.4 According to the FAR 25.853, the specimen thickness must be no thicker than the minimum thickness to be qualified for use in the airplane. If the test facility has found from experience or has questions concerning the flammability of a thicker specimen, then vertical testing may be conducted and test data recorded for further review.

1.5 As stated in the FAR 25.853, only one specimen may be removed at a time from the conditioning chamber prior to being subjected to the flame. Some facilities, however, have conditioning chambers located in areas remote from the testing area. In this case, it is permissible to remove more than one specimen at a time only if each specimen is placed in a closed container (a plastic stowage bag is acceptable) and protected from contamination such as dirty lab tops, soot in the air, etc., until the specimen is subjected to the flame.

1.6.2.2 Inserting the standard sized 3-inch (76-mm) -thick thermal/acoustic insulation test specimen into the Bunsen burner holder results in extreme compression of the blanket on the sides and an elliptical section on the bottom center. This configuration may compromise test results. The recommended method is to mount the specimen on the front face of the holder and use safety wire to secure it in place. It has been found that two pieces of safety wire, one wrapped around the 10-inch point and one wrapped around the 6-inch point, keep the sample flat and in place.

1.6.2.3 It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

1.6.2.4 More information is available in DOT/FAA/CT-86/22, “An Investigation of the FAA Vertical Bunsen Burner Flammability Test Method.” Appendix F, FAR 25.853, Part I describes this test and specifies that the flame be placed “along the centerline of the lower edge.” The “centerline of the lower edge” is the line from the front face to the back face of the specimen. For thicker specimens, this is ambiguous since exactly “where” along the “centerline of the lower edge” is not specified.

Historically, test practices regarding burner flame placement have not been uniform or consistent within either the FAA or aircraft manufacturers. The most common placement used in the past was specified in the original issue of this handbook, viz.:

For specimens that are 3/4 inch (19 mm) thick or less, place the burner barrel centerline under the center of the bottom surface of the specimen.

For specimens thicker than 3/4 inch (19 mm), center the burner barrel under the bottom surface of the specimen 3/8 inch (10 mm) in from the surface exposed to the airplane interior, test each surface separately unless the surfaces are of the same materials and construction.

Another placement that has been less commonly used is that specified here, viz., directly under the middle of the lower edge of the face of the specimen that is exposed to the airplane interior. For specimens thinner than the burner barrel thickness (3/8 inch; 10 mm), test results are relatively insensitive to exactly where "along the centerline of the lower edge" the burner flame is placed. For samples of greater thickness, however, burn lengths are typically an inch or so longer if the burner barrel centerline is placed under or near the specimen face, and flame times are sometimes a little longer than if the flame is placed per the original handbook, Report DOT/FAA/CT-89/15, September 1990.

Materials used in contemporary (especially postheat release) designs produce burn lengths and flame times that are considerably less than the acceptance criteria for certification (6 inches and 15 seconds), regardless of where the flame is placed. Although where the burner flame is applied is not of important pass/fail significance in this test, placing it directly under the specimen face generally represents a worst-case situation.

The FAA should accept data for certification using the flame placement described in the original portion of this handbook, or using the flame placed under the exposed face of the test specimen. However, the FAA and aircraft manufacturers have agreed that in the future, the preferred placement of the burner flame is under the middle of the lower edge of the face of the specimen.

1.6.2.5 If the burner extinguishes during the ignition time for any reason, rerun the test. From experience, it has been found that this is a necessary requirement when running a 12-second test. However, experience has also shown that if the flame extinguishes during a 60-second test, the test is not compromised by relighting the flame up to three times and adding up the ignition times. If the flame does extinguish, the flame must be relighted immediately. Failure to do so could result in the specimen cooling and compromising test results. The opposite end of the same specimen can be used for the retest if the burn length for the aborted test is less than 3 inches (76 mm). If the burn length for the aborted test is greater than 3 inches (76 mm), a new specimen must be used.

1.6.2.8 The operator should refer to the facility's safety manual for further information on dealing with smoke and flammability by-products.

Chapter 2
45-Degree Bunsen Burner Test for Cargo Compartment Liners and Waste Stowage Compartment Materials

2.1 Scope

This test method is intended for use in determining the resistance of materials to flame penetration and to flame and glow propagation when tested according to the 30-second, 45-degree Bunsen burner test specified in FAR 25.

2.2 Definitions

2.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. For this test, the ignition time is 30 seconds.

2.2.2 Flame Time

Flame time is the time in seconds that the specimen continues to flame after the burner flame is removed from under the specimen.

2.2.3 Glow Time

Glow time is the length of time in seconds that the specimen continues to glow after any flaming combustion ceases following the removal of the ignition flame.

2.2.4 Flame Penetration

Flame penetration occurs if the Bunsen burner flame penetrates (passes through) the test specimen through a hole or crack in the specimen that forms during the test ignition time. Flaming combustion on the top of the specimen that results from auto ignition is not considered flame penetration in this test.

2.3 Test Apparatus

2.3.1 Test Cabinet

Tests will be conducted in a draft-free cabinet as shown in figures 2-1 to 2-3 or other equivalent enclosures acceptable to the FAA. It is suggested that the cabinet be located inside an exhaust hood to facilitate clearing the cabinet of smoke after each test. Stainless steel or other corrosion resistant metal, 0.04 inch (1 mm) thick, will be used for the bottom surface of the chamber.

2.3.2 Specimen Holder

The specimen holder will be fabricated of corrosion-resistant metal and will be capable of securely positioning the specimen at a 45-degree angle, with the vertical as shown in figure 2-4. The holder will be able to accommodate specimens up to 1 inch (25 mm) thick.

2.3.3 Burner

The burner will be a Bunsen or Tirrill type, have a 3/8-inch (10-mm) inside diameter barrel, and will be equipped with a needle valve located at the bottom of the burner barrel to adjust the gas flow rate and, thereby, adjust the flame height (see figure 2-5). There will be a means provided to move the burner into and out of test position when the cabinet door is closed.

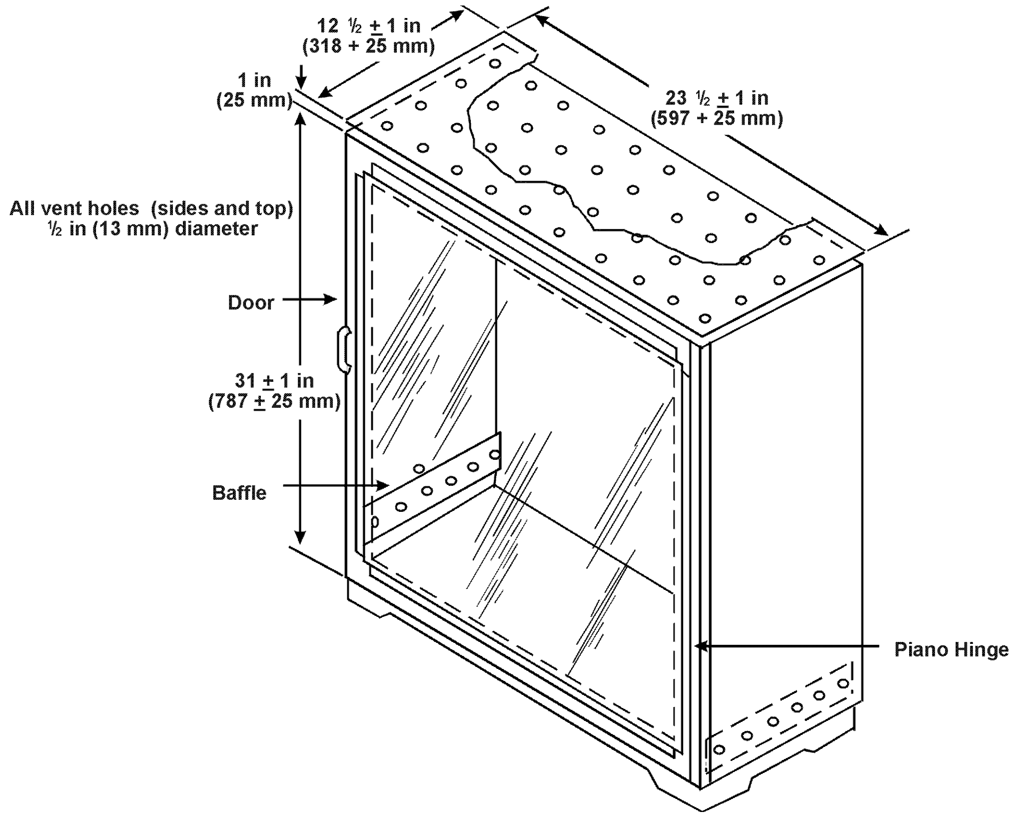

Figure 2-1. Sketch of 30-Second, 45-Degree Bunsen Burner Test Cabinet

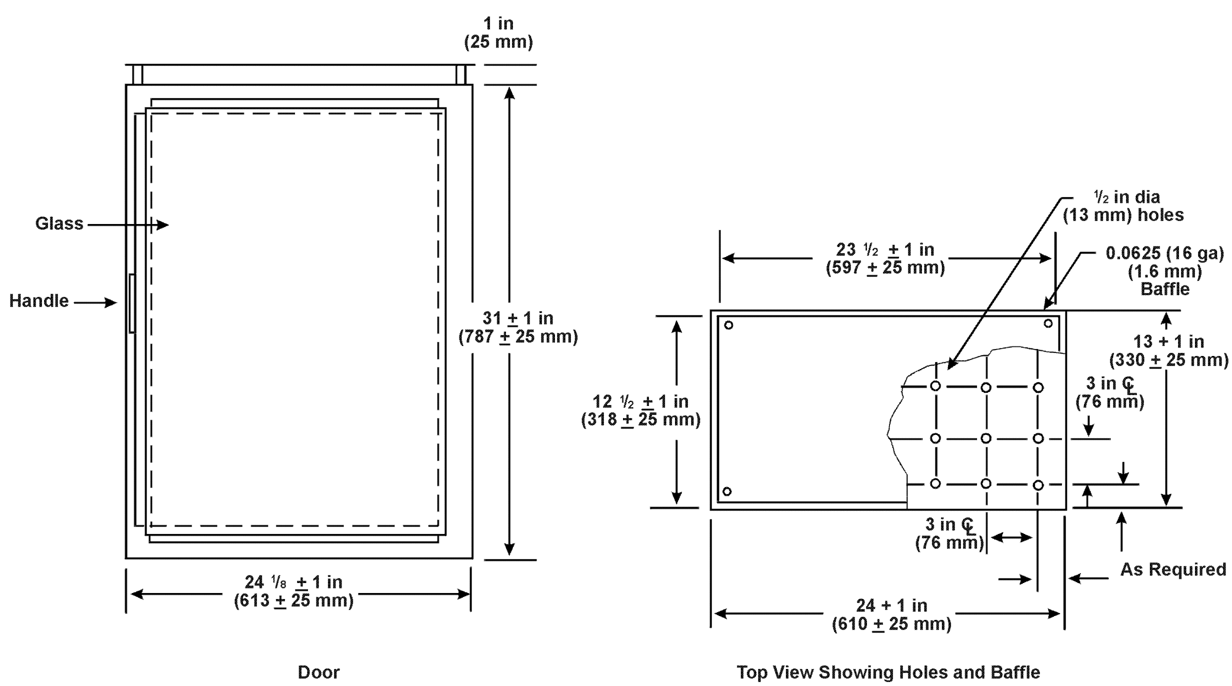

Figure 2-2. Front and Top View of 30-Second, 45-Degree Bunsen Burner Test Cabinet

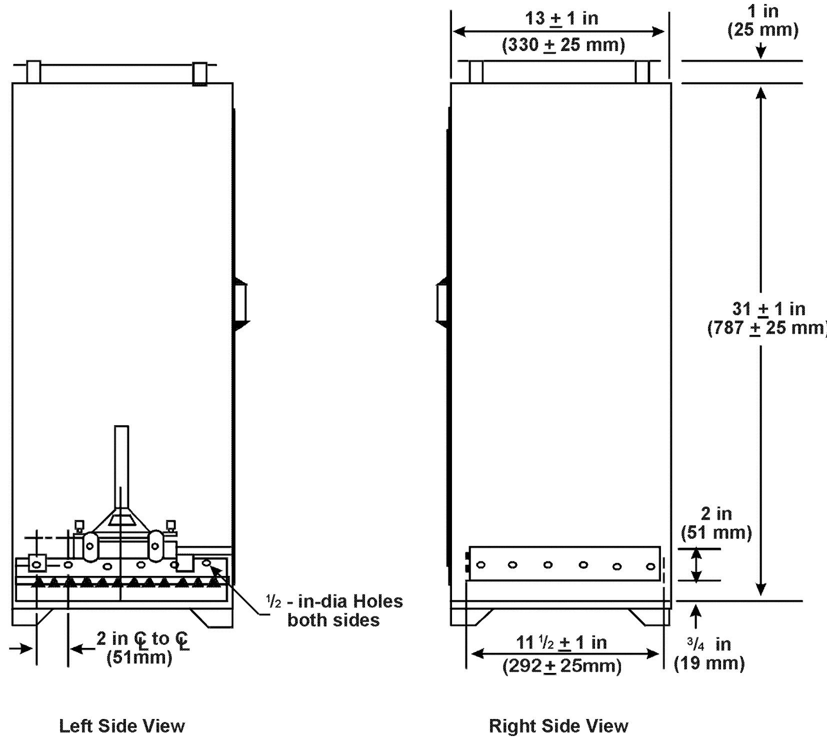

Figure 2-3. Side Views of 30-Second, 45-Degree Bunsen Burner Test Cabinet

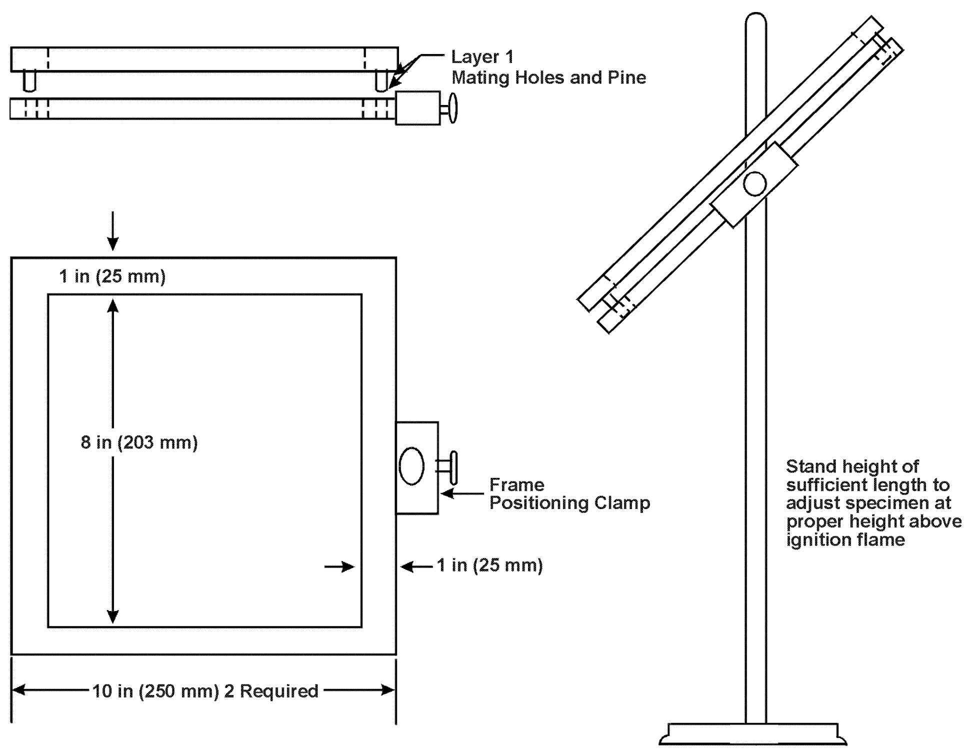

Figure 2-4. 30-Second, 45-Degree Bunsen Burner Test Specimen Frame and Stand

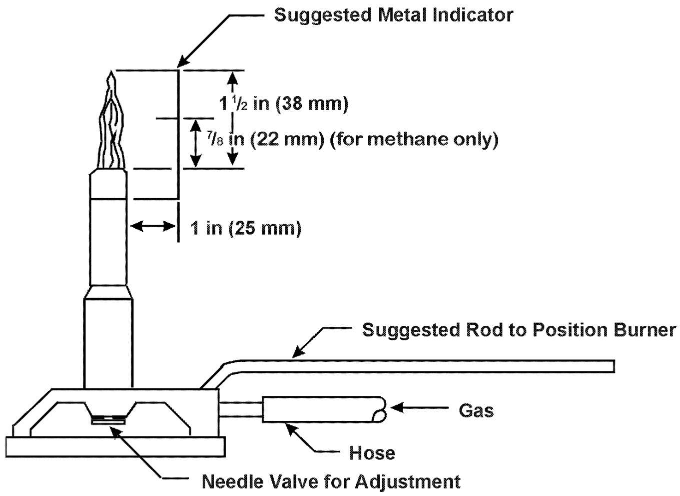

Figure 2-5. Burner Plumbing and Burner Flame Height Indicator

2.3.3.1 Burner Fuel

Methane gas (99 percent minimum purity) or other burner fuel acceptable to the FAA will be used. Methane is the preferred fuel. It can be used without adding air through the aspirating holes at the bottom of the burner barrel, i.e., a pure diffusion flame may be used.

2.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure 2-5. A control valve system with a delivery rate designed to furnish gas to the burner inlet under a pressure of 2 1/2 ± 1/4 psi (17 ± 2 kPa) at the burner inlet will be installed between the gas supply and the burner.

2.3.3.3 Flame Height Indicator

A flame height indicator may be used to aid in setting the height of the flame. A suitable indicator has a prong extending 1.5 inches (38 mm) above the top of the burner barrel, is attached to the burner barrel, and spaced 1 inch (25 mm) away from the burner barrel, as shown in figure 1-4. If using methane as the burner fuel, it is desirable to have two prongs for measuring the flame height, one prong to indicate the height of the inner cone of the flame and one prong to indicate the height of the tip of the flame. For methane, it has been determined that when the height of the inner cone is 7/8 inch (22 mm) and the tip of the flame is 1.5 inches (38 mm) long the proper flame profile is achieved.

2.3.3.4 Burner Positioning

There will be means provided to position the burner directly below the center of the specimen and also to move it at least 3 inches (76 mm) from the specimen.

2.3.4 Timer

A stopwatch or other device, calibrated to the nearest 0.1 second, will be used to measure the time of application of the burner flame, the flame time, and the glow time.

2.4 Test Specimens

2.4.1 Specimen Selection

Specimens tested will be either cut from a fabricated part as installed in the aircraft or cut from a section simulating a fabricated part, e.g., cut from a flat sheet of material or from a model of the fabricated part.

The specimen may be cut from any location in the fabricated part. Fabricated units, such as sandwich panels, will not be separated into individual component layers for testing.

2.4.2 Specimen Number

Each separate set of specimens prepared for testing will consist of at least three specimens (multiple places).

2.4.3 Specimen Size

The specimen will be a square large enough to allow an exposed area of 8 inches (203 mm) by 8 inches (203 mm). A nominal specimen size of 10 inches (254 mm) by 10 inches (254 mm) has been found satisfactory; however, actual specimen size is dependent upon the details of the specimen holder selected for the test equipment.

2.4.4 Specimen Thickness

The specimen thickness will be the same as that of the part to be qualified for use in the aircraft, with the following exceptions:

2.4.4.1 If the part construction is used in several thicknesses, the minimum thickness will be tested.

2.4.4.2 Parts that are smaller than the size of a specimen and cannot have specimens cut from them will be tested using a flat sheet of the material used to fabricate the part in the actual thickness used in the airplane.

2.5 Conditioning

Condition specimens at 70 ± 5°F (21 ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum. Remove only one specimen at a time from the conditioning environment immediately before testing.

2.6 Procedure

2.6.1 Burner Adjustment

2.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.

2.6.1.2 Open the stopcock in the gas line fully and light the burner.

2.6.1.3 Adjust the needle valve on the burner to achieve the proper 1.5-inch (38-mm) flame height in accordance with section 2.3.3.3.

2.6.2 Test Procedure

2.6.2.1 Place the burner at least 3 inches (76 mm) from where the edge of the specimen will be located during the test.

2.6.2.2 Place the specimen in the holder with the surface to be exposed when installed in the aircraft toward the flame. The specimen will be positioned so that one-third of the height of the flame is in contact with the material when the test is in progress.

2.6.2.3 Close the cabinet door, and keep it closed during the test.

2.6.2.4 The timer must be started immediately upon positioning the burner. Position the burner so that the center of the burner barrel is under the center of the bottom surface of the specimen, as shown in figure 2-6.

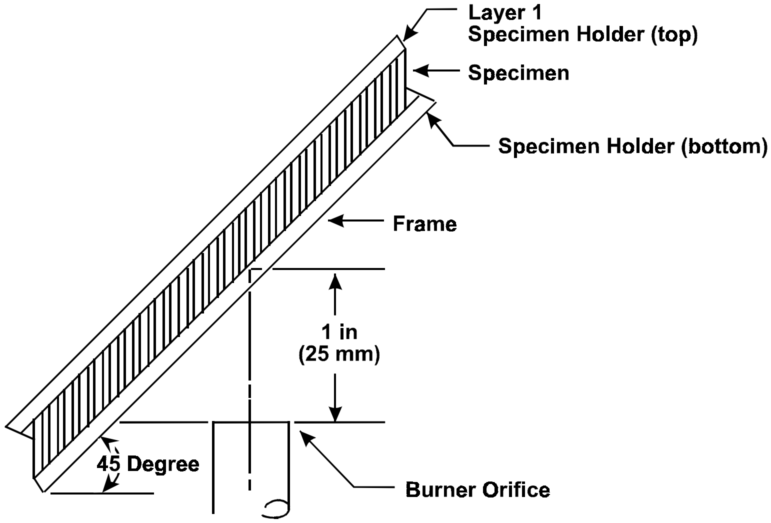

Figure 2-6. Flame Position on 30-Second, 45-Degree Bunsen Burner Test Specimen

2.6.2.5 Apply the flame for 30 seconds and then withdraw it by moving the burner at least 3 inches away from the specimen or by turning the gas off.

2.6.2.6 Determine the flame time for the specimen.

2.6.2.7 Determine the glow time for the specimen.

2.6.2.8 Determine if flame penetration occurs.

2.6.2.9 After all flaming ceases, open the cabinet door slowly to clear the test cabinet of fumes and smoke. The exhaust fan may be turned on to facilitate clearing of smoke and fumes. Remove any material from the bottom of the cabinet that fell from the specimen.

2.6.2.10 If necessary, clean the test cabinet window prior to testing the next specimen.

2.7 Report

2.7.1 Material Identification

Fully identify the material tested, including thickness.

2.7.2 Flame Time

Report the flame time for each specimen to the nearest 0.2 second. Determine and record the average flame time for all specimens tested.

2.7.3 Glow Time

Report the glow time for each specimen tested to the nearest second. Determine and record the average glow time for all specimens tested.

2.7.4 Flame Penetration

Report whether the Bunsen burner flame penetrated the specimen for each specimen tested.

2.8 Requirements

2.8.1 Flame Time

The average flame time for all specimens tested will not exceed 15 seconds.

2.8.2 Flame Penetration

The Bunsen burner flame will not penetrate any of the specimens tested.

2.8.3 Glow Time

The average glow time for all specimens tested will not exceed 10 seconds.

Chapter 2 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

2.2.1 Ignition time should start only after the flame has stabilized and is properly positioned under the test specimen.

2.3.1 Suitable test cabinets of the type described are manufactured by the U.S. Testing Co., 1415 Park Ave., Hoboken, New Jersey 07030; Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, Illinois 60613; and The Govmark Organization Inc., P.O. Box 807, Bellmore, New York 11710.

Draft free means a condition of no air currents in a closed in space for this test cabinet. One way of determining whether the cabinet is draft free is to place a smoldering and smoking material, such as a lighted cigarette, in the test cabinet, then closing the door and observing the behavior of the smoke for signs of drafts. A test cabinet other than one fabricated in accordance with figures 2-1 to 2-3 may be found to be acceptable after review by the FAA.

The entire inside back wall of the chamber may be painted flat black to facilitate viewing of the test specimen, and a mirror may be located on the inside back surface to facilitate observation of the hidden surfaces of the specimen.

2.3.3 A burner available as catalog number R3726A from Rascher & Betzold, Inc., 5410 N. Damen Ave., Chicago, Illinois 60625, has been found suitable.

2.3.3.1 Gases such as natural gas and propane can be used as burner fuel. However, it should be required to show compliance with the 1550°F minimum flame temperature using a 24 AWG thermocouple.

B-gas, which is the burner fuel specified in Federal Test Method 5903, meets minimum temperature requirements and is still used in some laboratories. However, its use has resulted in problems and is not recommended. See note below for more details.

NOTE: B-gas, a mixture of 55 percent hydrogen, 18 percent carbon monoxide, 24 percent methane, and 3 percent ethane, has shown inconsistent burning characteristics in steel cylinders. A "spike" of varying intensity is produced. It has been postulated that the carbon monoxide in the gas may react with the iron in the steel cylinders to produce iron pentcarbonyl ($Fe(CO)_5$), which is volatile and may cause interference with the normal flame characteristics and may be the cause of the erratic behavior. Because of the inconsistent flame characteristics, B-gas, at least if supplied in steel cylinders, is not recommended. No data are presently available about the suitability of B-gas supplied in cylinders of other materials, such as aluminum.

One noteworthy point that should be mentioned is the phenomenon that some labs have experienced sharp decreases in flame temperature after the gas cylinders are approximately three-fourths empty. This has occurred primarily in labs that have single-stage regulators on their gas cylinders. Single-stage regulators differ from two-stage regulators in that control of the discharge pressure is not as accurate. Few designs maintain constant or near constant discharge pressures over the full range of cylinder pressures. Therefore, it is necessary to make adjustments periodically to allow for decreasing inlet pressures. Even the slightest drop in pressure should affect the flow rate of gas through the burner orifice. This, in turn, should cause temperature variation. By using a two-stage regulator or adjusting pressure on a single-stage regulator, as the cylinder gets low, this problem can be eliminated.

2.3.3.3 The tip of the methane flame is blue, transparent, and difficult to see. It is more easily seen if there is no light on the flame, as in a darkened room. The inner cone of the flame is, however, more visible and easily seen.

2.4.4 According to the FAR 25.853, the specimen thickness must be no thicker than the minimum thickness to be qualified for use in the airplane. If the test facility has found from experience or has questions concerning the flammability of a thicker specimen, then vertical testing may be conducted and test data recorded for further review.

2.5 As stated in the FAR 25.853, only one specimen may be removed at a time from the conditioning chamber prior to being subjected to the flame. Some facilities, however, have conditioning chambers located in areas remote from the testing area. In this case, it is permissible to remove more than one specimen at a time only if each specimen is placed in a closed container (a plastic stowage bag is acceptable) and protected from contamination such as dirty lab tops, soot in the air, etc., until the specimen is subjected to the flame.

2.6.2.3 It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

2.6.2.5 Some laboratories turn the gas off upon completion of the test; however, the majority of test facilities, including the Original Equipment Manufacturers (OEMs), withdraw the flame by moving the burner away from the specimen.

2.6.2.9 The operator should refer to the facility's safety manual for further information dealing with smoke and flammability by-products.

Chapter 3
Horizontal Bunsen Burner Test for Cabin, Cargo Compartment, and Miscellaneous Materials

3.1 Scope

This test method is intended for use in determining the resistance of materials to flame when tested according to the 15-second horizontal Bunsen burner tests specified in FAR 25.853.

3.2 Definitions

3.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. For this test, the ignition time is 15 seconds.

3.2.2 Burn Rate

Burn rate is the rate at which a flame front moves over a specified distance on a test specimen, under specified test conditions. In this test, it is the rate with which a flame front moves across a test specimen mounted horizontally.

3.3 Apparatus

3.3.1 Test Cabinet

Tests will be conducted in a draft-free cabinet fabricated in accordance with figures 3-1 to 3-3 or other equivalent enclosures acceptable to the FAA. It is suggested that the cabinet be located inside an exhaust hood to facilitate clearing the cabinet of smoke after each test. Stainless steel or other corrosion resistant metal, 0.04 inch (1 mm) thick will be used for the bottom surface of the chamber.

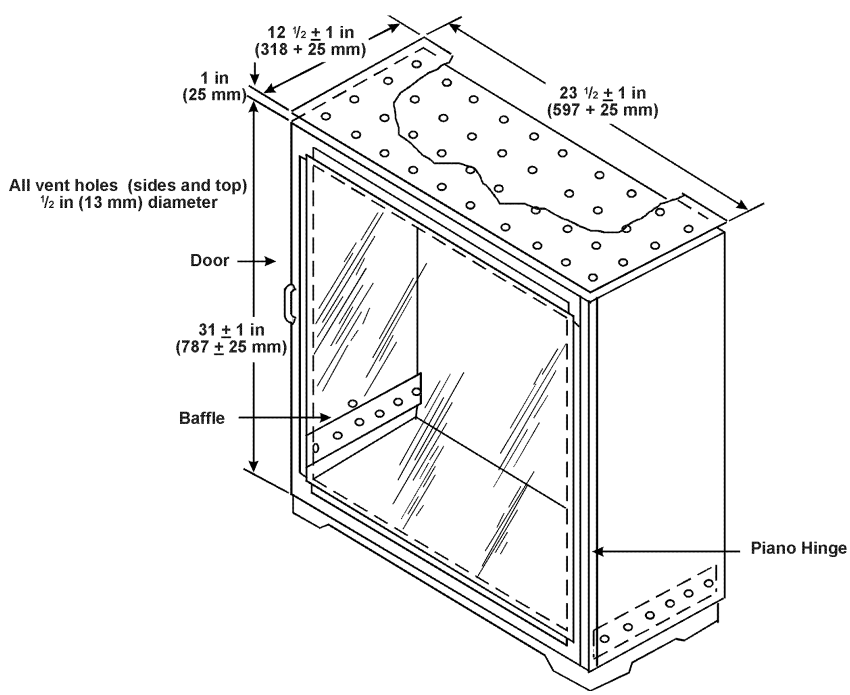

Figure 3-1. Sketch of Horizontal Bunsen Burner Test Cabinet

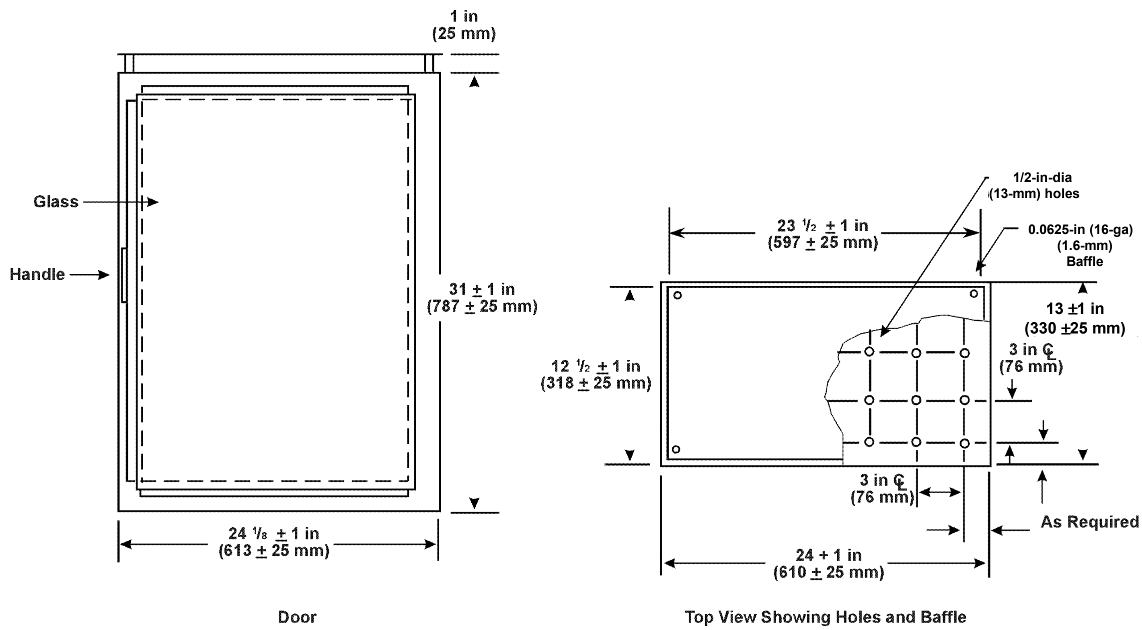

Figure 3-2. Front and Top View of Horizontal Bunsen Burner Test Cabinet

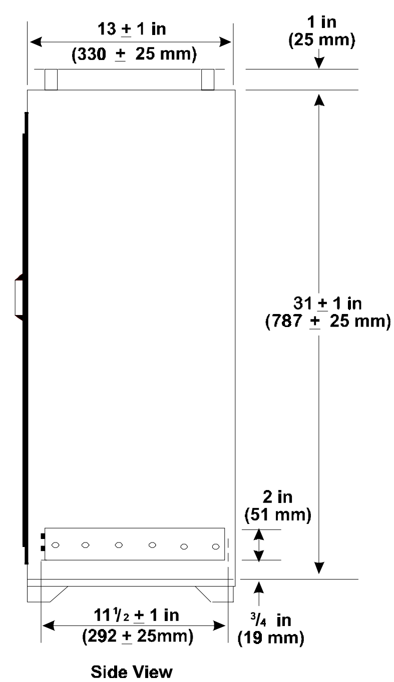

Figure 3-3. Side View of Horizontal Bunsen Burner Test Cabinet

3.3.2 Specimen Holder

A specimen holder fabricated of corrosion-resistant metal in accordance with figure 3-4 will be used. When performing the tests, the specimen will be mounted in the frame so that the two long edges are held securely. The exposed area of the specimen will be 2 inches (51 mm) in width and 12 inches (305 mm) in length.

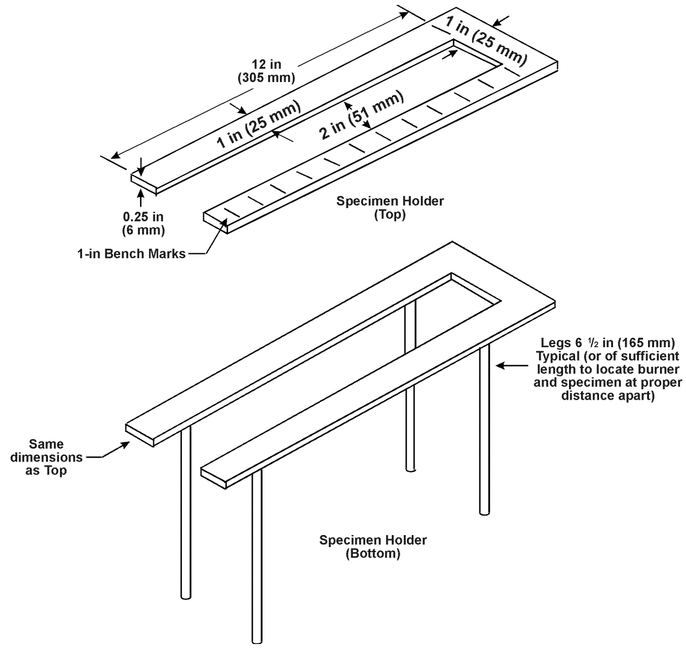

Figure 3-4. Horizontal Bunsen Burner Test Specimen Holder

3.3.3 Burner

The burner will be a Bunsen or Tirrill type, have a 3/8-inch (10-mm) inside diameter barrel, and will be equipped with a needle valve located at the bottom of the burner barrel to adjust the gas flow rate and, thereby, adjust the flame height. There will be a means provided to move the burner into and out of test position when the cabinet door is closed.

3.3.3.1 Burner Fuel

Methane gas (99 percent minimum purity) or other burner fuel acceptable to the FAA will be used. Methane is the preferred fuel. It can be used without adding air through the aspirating holes at the bottom of the burner barrel, i.e., a pure diffusion flame may be used.

3.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure 3-5. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2 1/2 ± 1/4 psi (17 ± 2 kPa) at the burner inlet will be installed between the gas supply and the burner.

3.3.3.3 Flame Height Indicator

A flame height indicator may be used to aid in setting the height of the flame. A suitable indicator has a prong extending 1.5 inches (38 mm) above the top of the burner barrel, is attached to the burner barrel, and spaced 1 inch (25 mm) from the burner barrel, as shown in figure 3-5. If using methane as the burner fuel, it is desirable to have two prongs for measuring the flame height, one prong to indicate the height of the inner cone of the flame and one prong to indicate the height of the tip of the flame. For methane, it has been determined that when the height of the inner cone is 7/8 inch (22 mm) and the tip of the flame is 1.5 inches (38 mm) long, the proper flame profile is achieved.

3.3.4 Timer

A stopwatch or other device, calibrated to the nearest 0.1 second, will be used to measure the time of application of the burner flame, the flame time, and the drip flame time.

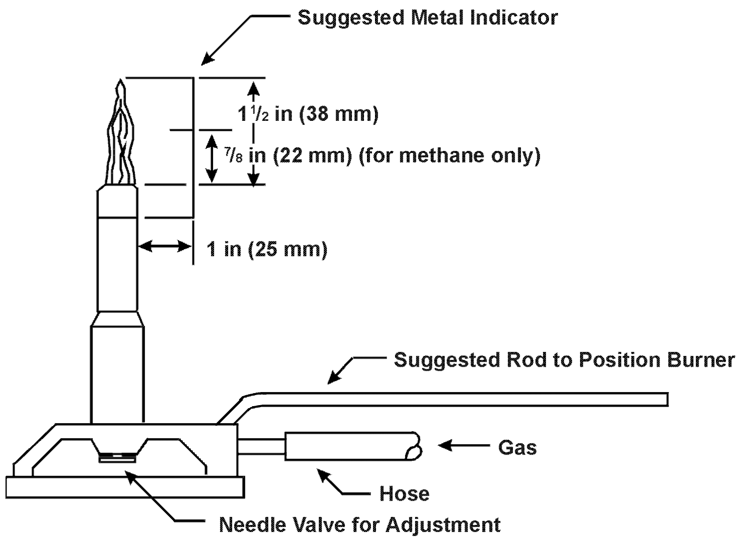

Figure 3-5. Burner Plumbing and Burner Flame Height Indicator

3.3.5 Ruler

A ruler or scale graduated to the nearest 0.1 inch (2.5 mm) will be provided to measure gage marks and flame front position.

3.4 Test Specimens

3.4.1 Specimen Selection

Specimens tested will be either cut from a fabricated part as installed in the aircraft or cut from a section simulating a fabricated part, e.g., cut from a flat sheet of material or from a model of the fabricated part. The specimen may be cut from any location in the fabricated part. Fabricated units, such as sandwich panels, will not be separated into individual component layers for testing.

3.4.2 Specimen Number

Each separate set of specimens prepared for testing will consist of at least three specimens (multiple places).

3.4.3 Specimen Size

The specimen will be a rectangle at least 3 by 12 inches (76 by 305 mm), unless the actual size used in the aircraft is smaller.

3.4.4 Specimen Thickness

The specimen thickness will be the same as that of the part qualified for use in the aircraft, with the following exceptions:

3.4.4.1 The specimen thickness must be no thicker than the minimum thickness to be qualified for use in the aircraft. The specimen thickness will not exceed 1/8 inch (3 mm).

3.4.4.2 Parts that are smaller than the size of a specimen and cannot have specimens cut from them may be tested using a flat sheet of the material used to fabricate the part in the actual thickness used in the aircraft. The sheet thickness will not exceed 1/8 inch (3 mm) if the test being run is the 4 inches per minute horizontal burn rate test.

3.4.5 Specimen Preparation

Mark gauge lines on the back surface (opposite the surface to be exposed to the flame) of the specimen 1.5 inches (38 mm) and 11.5 inches (292 mm) from the end of the specimen that will be subjected to the flame.

3.4.5.1 A fine-gauge wire mesh with large openings can be used to support test specimens that sag severely during testing so that the flame propagation may be determined accurately.

3.5 Conditioning

Condition specimens at 70 ± 5°F (21 ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum. Remove only one specimen at a time from the conditioning environment immediately before being tested.

3.6 Procedure

3.6.1 Burner Adjustment

3.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.

3.6.1.2 Open the stopcock in the gas line fully and light the burner.

3.6.1.3 Adjust the needle valve on the burner to achieve the proper 1.5-inch (38-mm) flame height in accordance with section 3.3.3.3.

3.6.2 Test Procedure

3.6.2.1 Place the burner at least 3 inches (76 mm) from where the specimen will be located during the test.

3.6.2.2 Insert the specimen face down (the exposed surface when installed in the aircraft) into the specimen holder so that the end of the specimen from which the 1.5-inch (38-mm) gauge mark was measured is flush with the open end of the specimen holder (see figure 3-6).

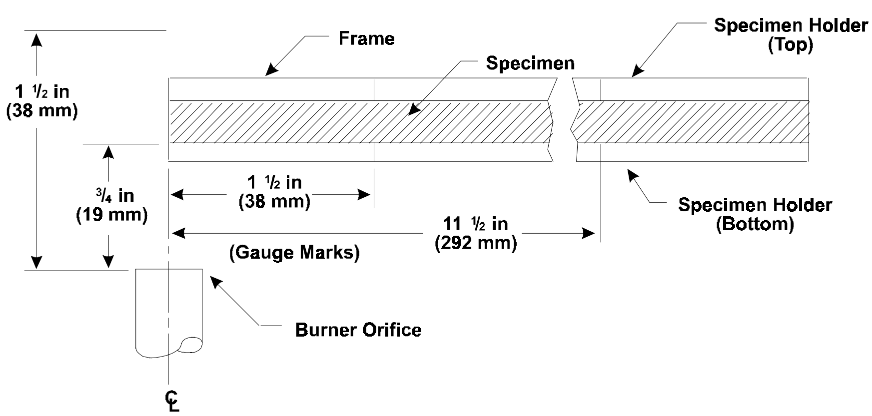

Figure 3-6. Typical Burner and Specimen Location

3.6.2.3 Close the cabinet door, and keep it closed during the test.

3.6.2.4 Start the timer immediately upon positioning the burner. Position the burner so that the centerline of the burner orifice is in line with the edge of the specimen holder and the centerline of the width of the specimen (see figure 3-6).

3.6.2.5 Apply the flame for 15 seconds and then withdraw it by moving the burner at least 3 inches (76 mm) from the specimen or by turning the gas off.

3.6.2.6 Note the times and/or locations on the specimen at which the following events occur:

3.6.2.6.1 If the flame front crosses the 1.5-inch (38-mm) gauge line, note the elapsed time in seconds, $t_e(1\ 1/2)$, at which the crossing occurs.

3.6.2.6.2 If the flame front crosses the 11.5-inch (292-mm) gauge line, note the elapsed time in seconds, $t_e(11\ 1/2)$, at which the crossing occurs.

3.6.2.6.3 If the specimen burns very slowly so that the flame front does not reach the 11.5-inch (292-mm) gauge line within 4 minutes after it passes the 1.5-inch (38-mm) gauge line, note the position in inches, d_f, of the flame front from the ignited end of the specimen and the elapsed time in seconds, $t_e(f)$, and terminate the test.

3.6.2.7 After all flaming ceases, open the cabinet door slowly to clear the test cabinet of fumes and smoke. The exhaust fan may be turned on to facilitate clearing of smoke and fumes. Remove any material from the bottom of the cabinet that fell from the specimen.

3.6.2.8 If necessary, clean the test cabinet window prior to testing the next specimen.

3.6.3 Test Results—Burn Rate

Determine the burn rate as follows:

3.6.3.1 If the flame front self-extinguished before crossing the 11.5-inch (292-mm) gauge line, record the burn rate as zero.

3.6.3.2 If the flame crosses the 11.5-inch (292-mm) gauge line, determine and record the burn rate as:

Burn rate (in/min) = 600/ $t_e(10)$, where $t_e(10) = t_e(11\ 1/2) - t_e\ (1\ 1/2)$ = time in seconds for the flame front to burn from the 1.5-inch (38-mm) gauge line to the 11.5-inch (292-mm) gauge line.

3.6.3.3 If the specimen burned very slowly (see section 3.6.2.6.3), the burn rate may be estimated and recorded as:

$$\text{Burn rate (in/min)} = 60 \times \frac{(d_f - 1.5)}{\left(t_e(f) - t_e\left(1\tfrac{1}{2}\right)\right)}$$

3.7 Report

3.7.1 Material Identification

Fully identify the material tested, including thickness.

3.7.2 Test Results

Report the burn rate from section 3.6.3 for each specimen tested. Determine and record the average value for burn rate.

3.8 Requirements

3.8.1 Burn rate

The average burn rate for all the specimens tested will not exceed 2.5 inches/minute for FAR 25.853(b-2) or 4 inches/minute for FAR 25.853(b-3), per Code of Federal Regulations (CFR), Title 14, January 1, 1990.

Chapter 3 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

3.2.1 Ignition time should start only after the flame has stabilized and is properly positioned under the test specimen.

3.3.1 Suitable test cabinets of the type described are manufactured by the U.S. Testing Co., 1415 Park Ave., Hoboken, New Jersey 07030; Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, Illinois 60613; and The Govmark Organization, Inc., P.O. Box 807, Bellmore, New York 11710.

Draft free implies a condition of no air currents in a closed in space. One way of determining whether the cabinet is draft free is to place a smoldering and smoking material, such as a lighted cigarette, in the test cabinet, then closing the door and observing the behavior of the smoke for signs of drafts. A test cabinet other than one fabricated in accordance with figures 3-1 to 3-3 may be found to be acceptable after review by the FAA.

The entire inside back wall of the chamber may be painted flat black to facilitate viewing of the test specimen, and a mirror may be located on the inside back surface to facilitate observation of the hidden surfaces.

3.3.3 A suitable burner is available from Rascher & Betzold, Inc., 5410 N. Damen Ave., Chicago, Illinois 60625, Catalog No. R3726A.

3.3.3.1 Gases such as natural gas and propane can be used as burner fuel. However, it should be required to show compliance with the 1550°F minimum flame temperature using a 24 AWG thermocouple.

B-gas, which is the burner fuel specified in Federal Test Method 5903, meets minimum temperature requirements and is still used in some laboratories. However, its use has resulted in problems, and is not recommended. See note below for more details.

NOTE: B-gas, a mixture of 55 percent hydrogen, 18 percent carbon monoxide, 24 percent methane, and 3 percent ethane, has shown inconsistent burning characteristics in steel cylinders. A "spike" of varying intensity is produced. It has been postulated that the carbon monoxide in the gas may react with the iron in the steel cylinders to produce iron pentcarbonyl ($Fe(CO)_5$), which is volatile and may cause interference with the normal flame characteristics and may be the cause of the erratic behavior. Because of the inconsistent flame characteristics, B-gas, at least if supplied in steel cylinders, is not recommended. No data are presently available about the suitability of B-gas supplied in cylinders of other materials, such as aluminum.

One noteworthy point that should be mentioned is the phenomenon that some labs have experienced with sharp decreases in flame temperature after the gas cylinders are approximately three-fourths empty. This has occurred primarily in labs that have single-stage regulators on their gas cylinders. Single-stage regulators differ from two-stage regulators in that control of the discharge pressure is not as accurate. Few designs maintain constant or near constant discharge pressures over the full range of cylinder pressures. Therefore, it is necessary to make adjustments periodically to allow for decreasing inlet pressures. Even the slightest drop in pressure should affect the flow rate of gas through the burner orifice. This, in turn, should cause temperature variation. By using a two-stage regulator or adjusting pressure on a single-stage regulator, as the cylinder gets low, this problem can be eliminated.

3.3.3.3 The tip of the methane flame is blue, transparent, and difficult to see. It is more easily seen if there is no light on the flame, as in a darkened room. The inner cone of the flame is, however, more visible and easily seen.

3.4.3 A 3-inch by 13-inch (76- by 330-mm) specimen can be used to secure the specimen at the end of the specimen holder.

3.4.4.1 According to the FAR 25.853, the specimen thickness must be no thicker than the minimum thickness to be qualified for use in the aircraft. If the test facility has found from experience or has questions concerning the flammability of a thicker specimen, then vertical testing may be conducted and test data recorded for further review.

3.5 As stated in the FAR 25.853, only one specimen may be removed at a time from the conditioning chamber prior to being subjected to the flame. Some facilities, however, have conditioning chambers located in areas remote from the testing area. In this case, it is permissible to remove more than one specimen at a time only if each specimen is placed in a closed container (a plastic stowage bag is acceptable) and protected from contamination such as dirty lab tops, soot in the air, etc., until the specimen is subjected to the flame.

3.6.2.3 It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

3.6.2.5 Some laboratories turn the gas off upon completion of the test; however, the majority of test facilities, including the OEMs, withdraw the flame by moving the burner away from the specimen.

3.6.2.7 The operator should refer to the facility's safety manual for further information dealing with smoke and flammability by-products.

Chapter 4
60-Degree Bunsen Burner Test for Electric Wire

4.1 Scope

This test method is intended for use in determining the resistance of electric wire insulation to flame when tested according to the 30-second, 60-degree Bunsen burner test specified in FAR 25.869.

4.2 Definitions

4.2.1 Ignition Time

Ignition time is the length of time the burner flame is applied to the specimen. The ignition time for this test is 30 seconds.

4.2.2 Flame Time

Flame time is the time in seconds that the specimen continues to flame after the burner flame is removed from beneath the specimen. Surface burning that results in a glow but not in a flame is not included.

4.2.3 Drip Flame Time

Drip flame time is the time in seconds that any flaming material continues to flame after falling from the specimen to the floor of the chamber. If there is more than one drip, the drip flame time reported is that of the longest flaming drip. If succeeding flaming drips reignite earlier drips that flamed, the drip flame time reported is the total of all flaming drips.

4.2.4 Burn Length

Burn length is the length of damage along the wire above and below the point of burner flame impingement and due to that area's combustion, including areas of partial consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discolored nor areas where material has shrunk or melted away from the heat.

4.3 Apparatus

4.3.1 Test Enclosure and Setup

Tests will be conducted in a cabinet fabricated of sheet metal, approximately 24 inches (610 mm) high by 12 inches (305 mm) wide by 12 inches (305 mm) deep and open at the front and top. External conditions around the cabinet will be such that the cabinet is free of drafts during a test, but sufficient airflow will be available for complete combustion. Other cabinets may be used if they are draft free and have enough air to allow complete combustion. It is suggested that the cabinet be located inside an exhaust hood to facilitate removal of smoke and fumes after each test.

4.3.2 Specimen Holder

A specimen holder fabricated of corrosion-resistant metal in accordance with figure 4-1 will be used. The specimen holder will be placed so that the specimen is maintained at an angle of 60 degrees with the horizontal and is positioned parallel to and 6 inches (152 mm) back from the front of the enclosure.

4.3.2.1 Clamp and Pulley

The specimen will be attached to the specimen holder by a clamp at the lower end and a pulley or rod at the upper end. The span between the clamp and the rod or pulley will be 24 inches (610 mm).

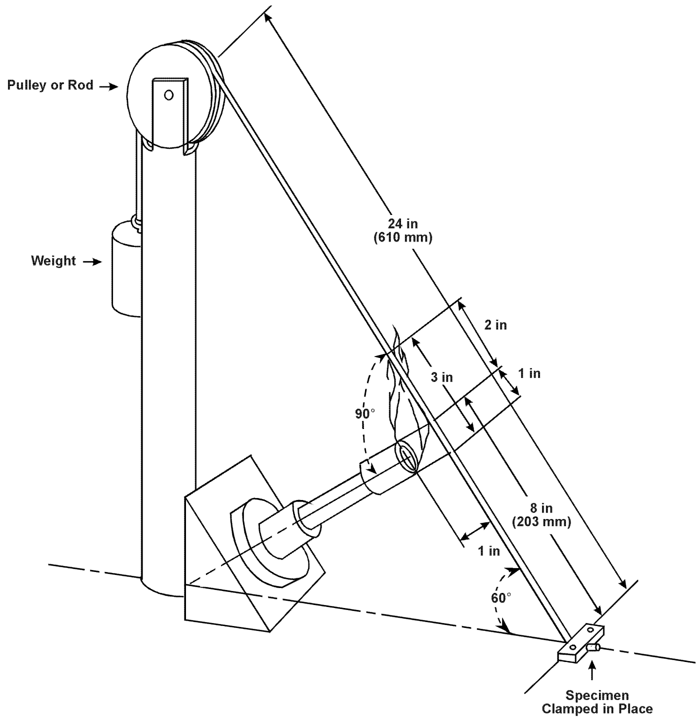

Figure 4-1. 60-Degree Electrical Wire Bunsen Burner Test Setup

4.3.2.2 Weight

A weight will be attached to the free end of the specimen to keep the specimen taut during the test (see figure 4-1). Suggested weights for various wire sizes are shown in table 4-1.

Table 4-1. Wire Size and Weight Suggestions

AWG	Pounds	Kg
20	0.8	0.4
14	2.0	0.9
8	3.0	1.4
1/0	11.0	5.0

4.3.3 Burner

The burner will be a Bunsen or Tirrill type, have a 3/8-inch (10-mm) inside diameter barrel and be equipped with a needle valve at the bottom of the burner barrel to adjust the gas flow rate (see figure 4-2). A means will be provided to move the burner into and out of the test position. Mounting the burner on a fixture that allows it to be rotated in the horizontal plane is suggested.

4.3.3.1 Burner Fuel

Methane gas (99 percent minimum purity) or other burner fuel acceptable to the FAA will be used. Methane is the preferred fuel. It can be used without adding air through the aspirating holes at the bottom of the burner barrel, i.e., a pure diffusion flame may be used.

4.3.3.2 Plumbing for Gas Supply

The necessary gas connections and the applicable plumbing will be essentially as shown in figure 4-2. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 2 1/2 ± 1/4 lb/ft^2 (17 ± 2 kPa) at the burner inlet will be installed in between the gas supply and the burner.

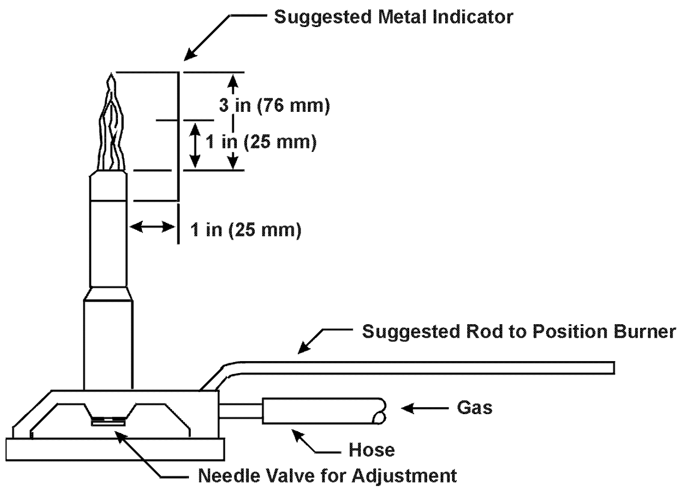

Figure 4-2. Burner Plumbing and Burner Flame Height Indicator

4.3.3.3 Flame Height Indicator

A flame height indicator may be used to aid in setting the height of the flame. A suitable indicator has a prong 3 inches (76 mm) above the top of the barrel, is attached to the burner barrel, spaced 1 inch (25 mm) from the burner barrel, and extends above the burner, as shown in figure 4-2. It is desirable to have two prongs to measure flame height, one prong to indicate the height of the inner cone of the flame and one prong to indicate the height of the tip of the flame. For this test, it has been determined that when the height of the inner cone is 1 inch (25 mm) and the tip of the flame is 3 inches (76 mm), the proper flame profile is achieved.

4.3.4 Timer

A stopwatch or other device graduated to the nearest 0.1 second will be used to measure the time of application of the burner flame, the flame time, and the drip flame time.

4.3.5 Ruler

A ruler or scale graduated to the nearest 0.1 inch (2.5 mm) will be provided to measure the burn length.

4.4 Test Specimens

4.4.1 Specimen Number

Each separate set of specimens prepared for testing will consist of at least three specimens (multiple places).

4.4.2 Specimen Length

The specimens will be cut to a length of 30 inches (762 mm). The specimen span between the lower clamp and upper pulley or rod will be 24 inches (610 mm).

4.4.3 Specimen Preparation

Make a gauge mark 8 inches (203 mm) from one end of each specimen.

4.5 Conditioning

Condition specimens at 70 ± 5°F (21 ± 3°C) and 50% ± 5% relative humidity for 24 hours minimum unless otherwise specified. Remove only one specimen at a time from the conditioning environment immediately before being tested.

4.6 Procedure

4.6.1 Burner Adjustment

4.6.1.1 If using methane as the burner fuel, ensure that the air supply to the burner is shut off.

4.6.1.2 Open the stopcock in the gas line fully and light the burner.

4.6.1.3 Adjust the burner flame to obtain a flame profile so that the outer cone of the flame is 3 inches (76 mm) in length and the inner cone is approximately 1 inch (25 mm) in length. The proper flame length will be obtained by adjusting the needle valve on the burner controlling the gas flow rate.

4.6.1.4 Burner Placement

For the test, place the burner into position so that the top end of the burner barrel is 1 inch from the mark on the specimen, and the centerline of the burner barrel is perpendicular to the specimen and intersects the specimen at the mark (see figure 4-1).

4.6.2 Test Procedure

4.6.2.1 Place the burner at least 3 inches (76 mm) from where the specimen will be located during the test.

4.6.2.2 The timer must be started immediately upon positioning the burner. Position the burner as described in section 4.6.1.4 so that the tip of the inner cone of the burner flame contacts the gauge mark on the wire.

4.6.2.3 Apply the flame for 30 seconds, and then withdraw it.

4.6.2.4 If flaming material falls from the test specimen, note the drip flame time for the specimen (see section 4.2.3).

4.6.2.5 Determine the flame time for the specimen (see section 4.2.2).

4.6.2.6 After all flaming ceases, remove the specimen and determine the burn length (see section 4.2.4). To facilitate determining the burn length, a dry soft cloth or tissue or a soft cloth or tissue dampened with a moderate solvent that does not dissolve or attack the specimen material, such as alcohol, may be used to remove soot and stain particles from tested specimens.

4.6.2.7 Remove any material from the bottom of the cabinet that fell from the specimen.

4.7 Report

4.7.1 Material Identification

Fully identify the wire tested.

4.7.2 Test Results

4.7.2.1 Report the flame time for each specimen tested. Determine and record the average value for flame time.

4.7.2.2 Report the drip flame time for each specimen tested. Determine and record the average value for drip flame time. For specimens that have no drips, record “0” for the drip flame time and also record “No Drips.”

4.7.2.3 Report the burn length for each specimen tested. Determine and record the average value for burn length.

4.8 Requirements

4.8.1 Extinguishing Time

The average extinguishing time for all the specimens tested will not exceed 30 seconds.

4.8.2 Drip Extinguishing Time

The average drip extinguishing time for all the specimens tested will not exceed 3 seconds.

4.8.3 Burn length

The average burn length for all the specimens tested will not exceed 3 inches (76 mm).

4.8.4 Wire Breakage

It will not be considered a failure if the wire breaks during the test.

Chapter 4 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

4.2.1 Ignition time should start only after the flame has stabilized and is properly positioned under the test specimen.

4.3.1 Draft free implies a condition of no air currents in a closed in space. One way of determining whether the cabinet is draft free is to place a smoldering and smoking material, such as a lighted cigarette, in the test cabinet, then closing the door and observing the behavior of the smoke for signs of drafts. A test cabinet other than one described in section 4.3.1 may be found to be acceptable after review by the FAA.

The entire inside back wall of the chamber may be painted flat black to facilitate viewing of the test specimen, and a mirror may be located on the inside back surface to facilitate observation of the hidden surfaces.

4.3.3 A suitable burner is available from Rascher & Betzold, Inc., 5410 N. Damen Ave., Chicago, Illinois 60625, Catalog No. R3726A.

4.3.3.1 Gases such as natural gas and propane can be used as burner fuel. However, it should be required to show compliance with the 1750°F minimum flame temperature using a 24 AWG thermocouple.

B-gas, which is the burner fuel specified in Federal Test Method Standard 5903, meets minimum temperature requirements and is still used in some laboratories. However, its use has resulted in problems and is not recommended. See note below for more details.

NOTE: B-gas, a mixture of 55 percent hydrogen, 18 percent carbon monoxide, 24 percent methane, and 3 percent ethane, has shown inconsistent burning characteristics in steel cylinders. A “spike” of varying intensity is produced. It has been postulated that the carbon monoxide in the gas may react with the iron in the steel cylinders to produce iron pentcarbonyl ($Fe(CO)_5$), which is volatile and may cause interference with the normal flame characteristics and may be the cause of the erratic behavior. Because of the inconsistent flame characteristics, B-gas, at least if supplied in steel cylinders, is not recommended. No data are presently available about the suitability of B-gas supplied in cylinders of other materials, such as aluminum.

A phenomenon that some labs have experienced is a sharp decrease in flame temperature after about three-fourths of the gas originally in the cylinder has been used. This has occurred primarily in labs that have single-stage regulators on their gas cylinders. Single-stage regulators differ from two-stage regulators in that control of the discharge pressure is not as accurate. Few designs should maintain constant or near constant discharge pressures over the full range of cylinder pressures. Therefore, it is necessary to make adjustments periodically to allow for decreasing inlet pressures. Even the slightest drop in pressure should affect the flow rate of gas through the burner orifice. This, in turn, should cause temperature variation. By using a two-stage regulator or adjusting pressure on a single-stage regulator, as the cylinder gets low, this problem can essentially be eliminated.

4.5 As stated in FAR 25.853, only one specimen may be removed at a time from the conditioning chamber prior to being subjected to the flame. Some facilities, however, have conditioning chambers located in areas remote from the testing area. In this case, it is permissible to remove more than one specimen at a time only if each specimen is placed in a closed container (a plastic stowage bag is acceptable) and protected from contamination such as dirty lab tops, soot in the air, etc., until the specimen is subjected to the flame.

4.6.1.4 Alternative Burner Placement

Place the burner into position so that the top end of the burner barrel is 1 inch from the mark on the specimen. Make sure the centerline of the burner barrel is perpendicular to the underside of the mark on the specimen, that the centerline of the burner barrel forms an angle of 30 degrees with the line that is in the vertical plane containing both ends of the specimen, is perpendicular to the specimen, and passes through the mark on the specimen. It has been found convenient to fabricate a fixture to position and hold the location of the burner quickly and repeatably (see figure 4-3).

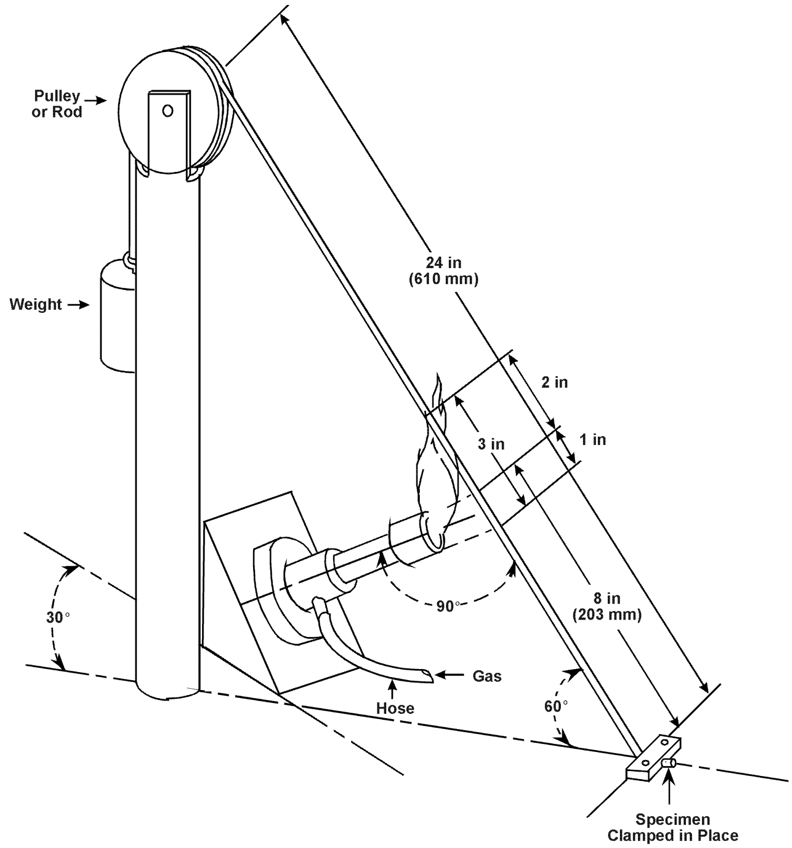

Figure 4-3. Alternative Setup for 60-Degree Electrical Wire Bunsen Burner Test

4.6.2.3 It is important to note that the test should be watched carefully while it is being conducted. This applies to all samples.

4.6.2.6 The operator should refer to the facility's safety manual for further information dealing with smoke and flammability by-products.

NOTE: The Alternative Burner Placement conforms to the 30-second, 60-degree Bunsen burner test described in FAR 25, Appendix F, Part I through Amendment 25-72. The FAA William J. Hughes Technical Center has determined that the Burner Placement in section 4.6.1.4 produces equivalent test results.

Chapter 5
Heat Release Rate Test for Cabin Materials

5.1 Scope

5.1.1 This test is intended for use in determining heat release rates to show compliance with the requirements of FAR 25.853.

5.1.2 Heat release rate is measured for the duration of the test from the moment the specimen is injected into the controlled exposure chamber and encompasses the period of ignition and progressive flame involvement of the surface.

5.2 Definitions

5.2.1 Heat Release

Heat release is a measure of the amount of heat energy evolved by a material when burned. It is expressed in terms of energy per unit area (kilowatt minutes per square meter—kW min/m^2).

5.2.2 Heat Release Rate

Heat release rate is a measure of the rate at which heat energy is evolved by a material when burned. It is expressed in terms of power per unit area (kilowatts per square meter—kW/m^2). The maximum heat release rate occurs when the material is burning most intensely.

5.2.3 Heat Flux

Heat flux density is the intensity of the thermal environment to which a sample is exposed when burned. In this test, the heat flux density used is 3.5 W/cm^2.

5.3 Test Apparatus

5.3.1 Release Rate Apparatus

The apparatus shown in figures 5-1a and 5-1b will be used to determine heat release rates. All exterior surfaces of the apparatus, except the holding chamber, will be insulated with 1-inch (25-mm) thick, low-density, high-temperature, fiberglass board insulation. A gasketed door through which the sample injection rod slides will be provided to form an airtight closure on the specimen holding chamber.

5.3.2 Thermopile

The temperature difference between the air entering and leaving the environmental chamber will be monitored by a thermopile having five hot and five cold 24-gauge chromel-alumel junctions (see figure 5-2). The bead to be formed by the thermocouple junction will be 0.050 ± 0.010 inch (1.3 ± 0.3 mm) in diameter. Each junction will be free of insulation for a minimum of 0.75 inch (19 mm). The cold junctions will be located in the pan below the air distribution plate (see section 5.3.4). The hot junctions will be located 0.38 inch (10 mm) below the top of the chimney. One of the hot junctions will be placed at the center of the chimney's cross section, and the other four will be placed on the chimney diagonals, 1.18 inches (30 mm) from the center thermocouple.

5.3.3 Radiant Heat Source

A radiant heat source for generating a flux up to 10 W/cm^2, using four silicon carbide elements Type LL, 20 inches (508 mm) by 0.63 inch (16 mm), nominal resistance 1.4 ohms, as shown in figures 5-1a, 5-1b, and 5-3, will be used. The silicon carbide elements will be mounted in the stainless steel panel box by inserting them through 0.63 inch (16-mm) holes in ceramic insulating devices or calcium-silicate millboard. Locations of the holes in the pads and stainless steel covered plates will be as shown in figure 5-3. A truncated, diamond-shaped mask, constructed of 0.042 ± 0.002 inch (1.07 ± 0.05 mm) stainless steel, will be added to provide uniform heat flux density over the area occupied by the 5.94- by

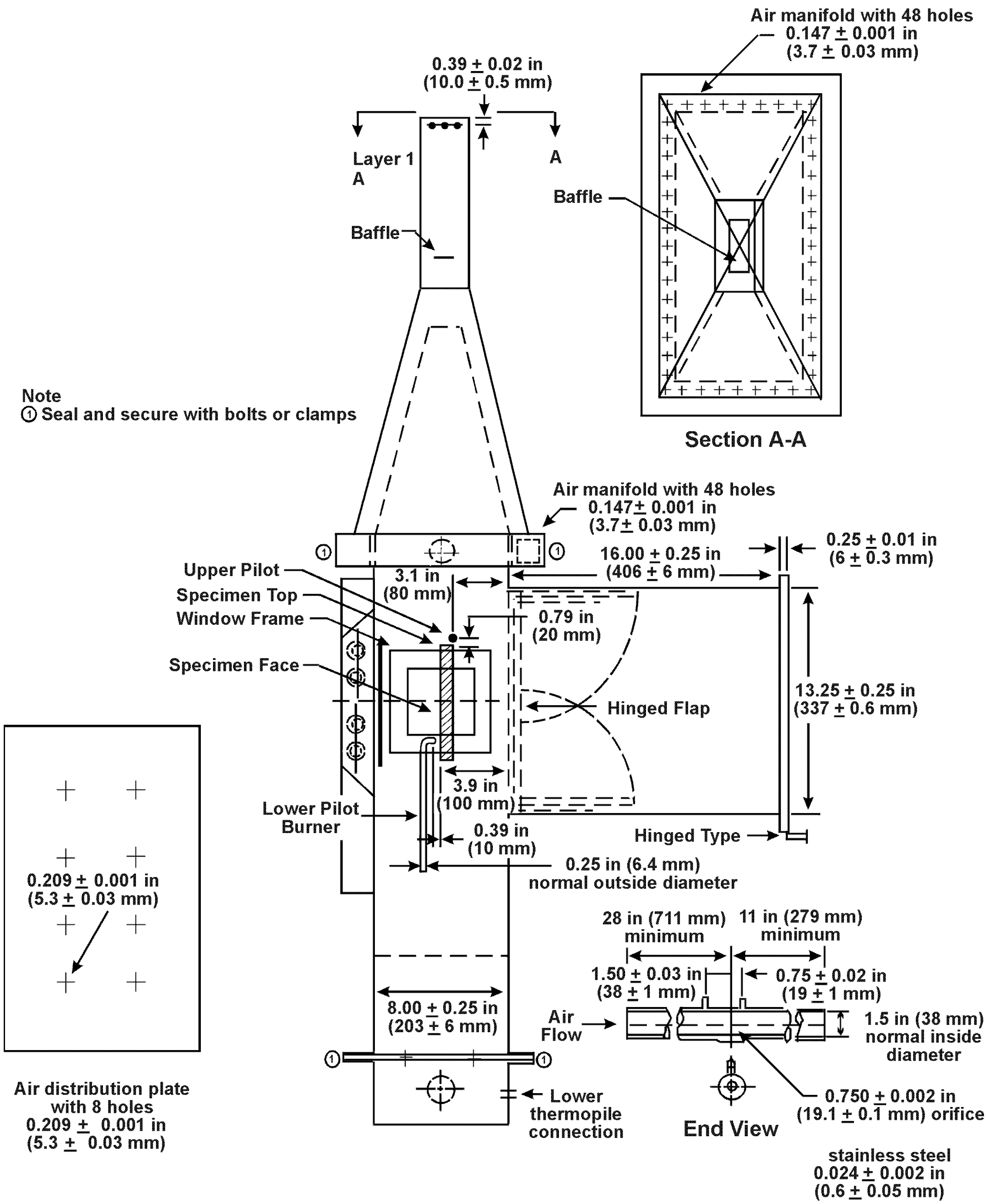

Figure 5-1a. Rate of Heat Release Apparatus

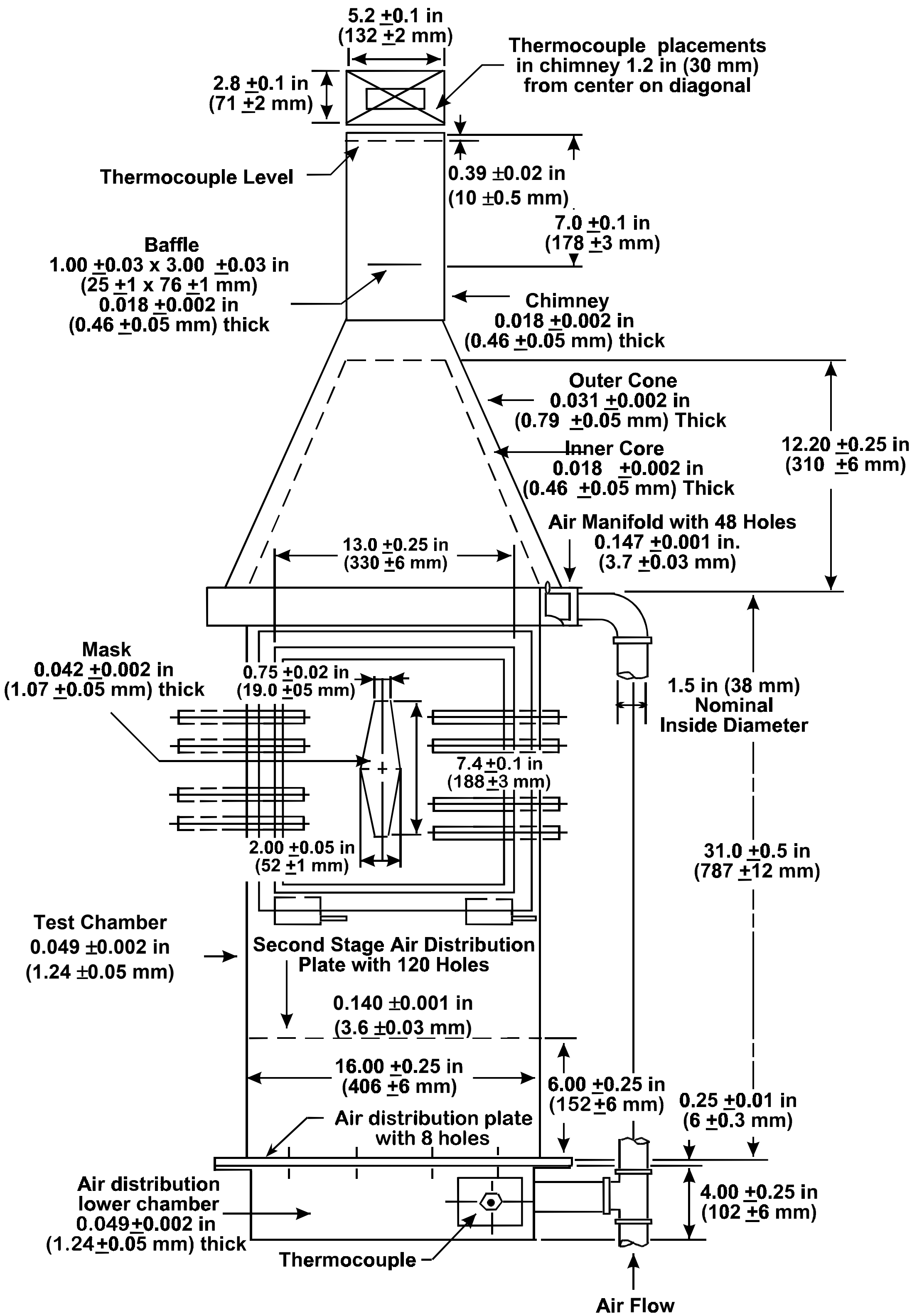

Figure 5-1b. Rate of Heat Release Apparatus

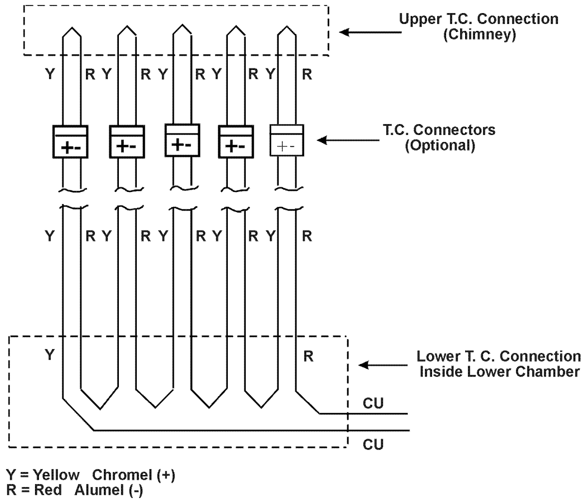

Figure 5-2. Thermopile

5.94-inch (151- by 151-mm) vertical sample. An adjustable power supply capable of producing 12.5 kVA will be provided. The heat flux over the specimen surface when set at 3.5 W/cm^2 will be uniform within 5 percent and will be checked periodically and after each heating element change. Uniformity of heat flux density will be determined by heat flux sensor measurements at the center and at the four corners of the specimen surface.

5.3.4 Air Distribution System

The air entering the apparatus will be 70 to 75°F (21 to 24°C) and set at approximately 85 ft^3/min (0.04 m^3/s) using an orifice meter. The orifice meter will be comprised of a squared-edged, circular plate orifice, 0.024 inch (0.5 mm) thick, located in a circular pipe with a nominal diameter of 1.5 inches (38 mm), with two pressure measuring points located 1.5 inches (38 mm) upstream (above) and 0.75 inch (19 mm) downstream (below) the orifice and connected to a mercury manometer. The inlet pipe will remain a nominal diameter of 1.5 inches (38 mm) (see figure 5-la).

5.3.4.1 The air entering the environmental chamber will be distributed by a 0.25-inch (6.3-mm) -thick aluminum plate having eight 0.209- ± 0.001-inch (5.3- ± 0.03-mm) -diameter holes, 2 inches (51 mm) from the sides on 4-inch (102-mm) centers, mounted at the base of the environmental chamber. A second plate having 120 evenly spaced, 0.140- ± 0.001-inch (3.6- ± 0.03-mm) -diameter holes, will be mounted 6 inches (152 mm) above the aluminum plate (see figure 5-1b).

5.3.4.2 The air supply manifold at the base of the pyramidal section will have 48 evenly spaced, 0.147- ± 0.001-inch (3.7- ± 0.03-mm) -diameter holes 0.38 inch (10 mm) from the inner edge of the manifold, resulting in an airflow split of approximately three to one within the apparatus (see figure 5-1a).

5.3.5 Exhaust Stack

An exhaust stack, 5.25 by 2.75 inches (133 by 70 mm) in cross section and 10 inches (254 mm) long, fabricated from stainless steel, 0.018 ± 0.002 inch (0.46 ± 0.05 mm), will be mounted on the outlet of the pyramidal section (see figures 5-1a and 5-1b). A 1- by 3-inch (25- by 76-mm) plate of 0.018- ± 0.002-inch (0.46- ± 0.05-mm) -thick stainless steel will be centered inside the stack, perpendicular to the airflow, 3 inches (76 mm) above the base of the stack.

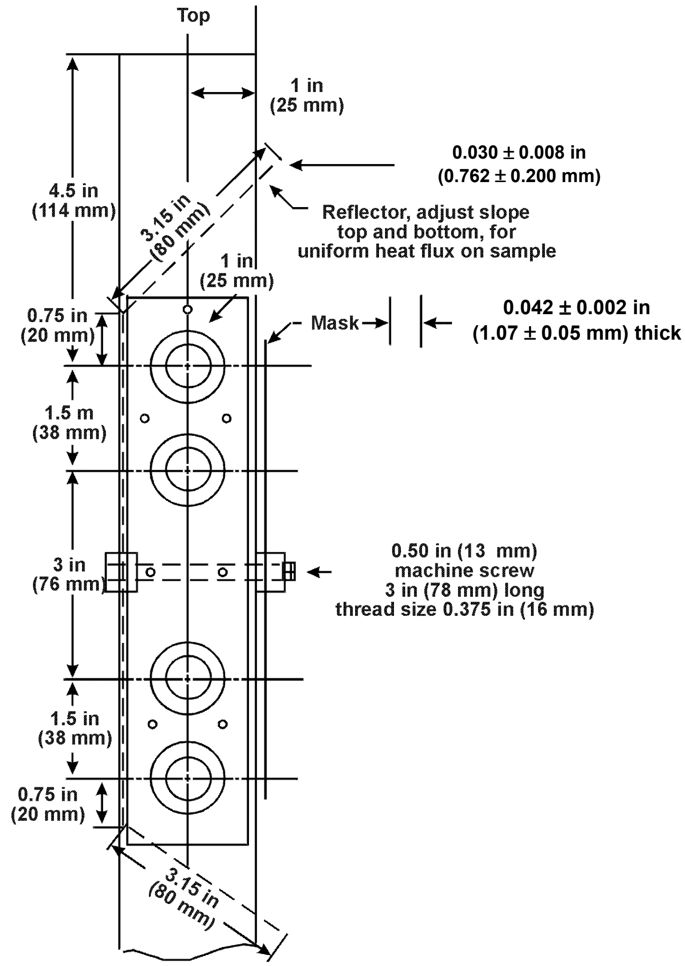

Figure 5-3. Side View—Global Radiant Heat Panel

5.3.6 Specimen Holders

Specimen holders will be fabricated from a stainless steel sheet, 0.018 ± 0.002 inch (0.46 ± 0.05 mm) thick, as shown in figure 5-4. Specimen holders will be attached to the injection rod using the mounting bracket shown in figure 5-4. Each holder will be provided with a V-shaped spring pressure plate. The position of the spring pressure plate can be changed to accommodate different specimen thicknesses by inserting the retaining rod in different holes of the specimen holder frame. Each holder will also have two wires attached vertically to the front of the holder to secure the face of the specimen in the holder.

5.3.6.1 Drip Pan

A drip pan will be fabricated from a stainless steel sheet, 0.018 ± 0.002 inch (0.46 ± 0.05 mm) thick, as shown in figure 5-4, and be attached to the specimen holder using the flanges shown in figure 5-4. Drip pans may be needed to prevent melting specimens from dripping into the lower test section. Foil can be used to line the drip pan to facilitate cleaning after use.

5.3.7 Heat Flux Sensor

A water-cooled, foil-type Gardon Gauge heat flux sensor will be used to measure the heat flux density at a point where the center of the specimen surface is located at the start of the test. When positioned to measure heat flux density, the sensor surface will be flush with the supporting device surface so that air heated by such a support does not contact the sensor surface.

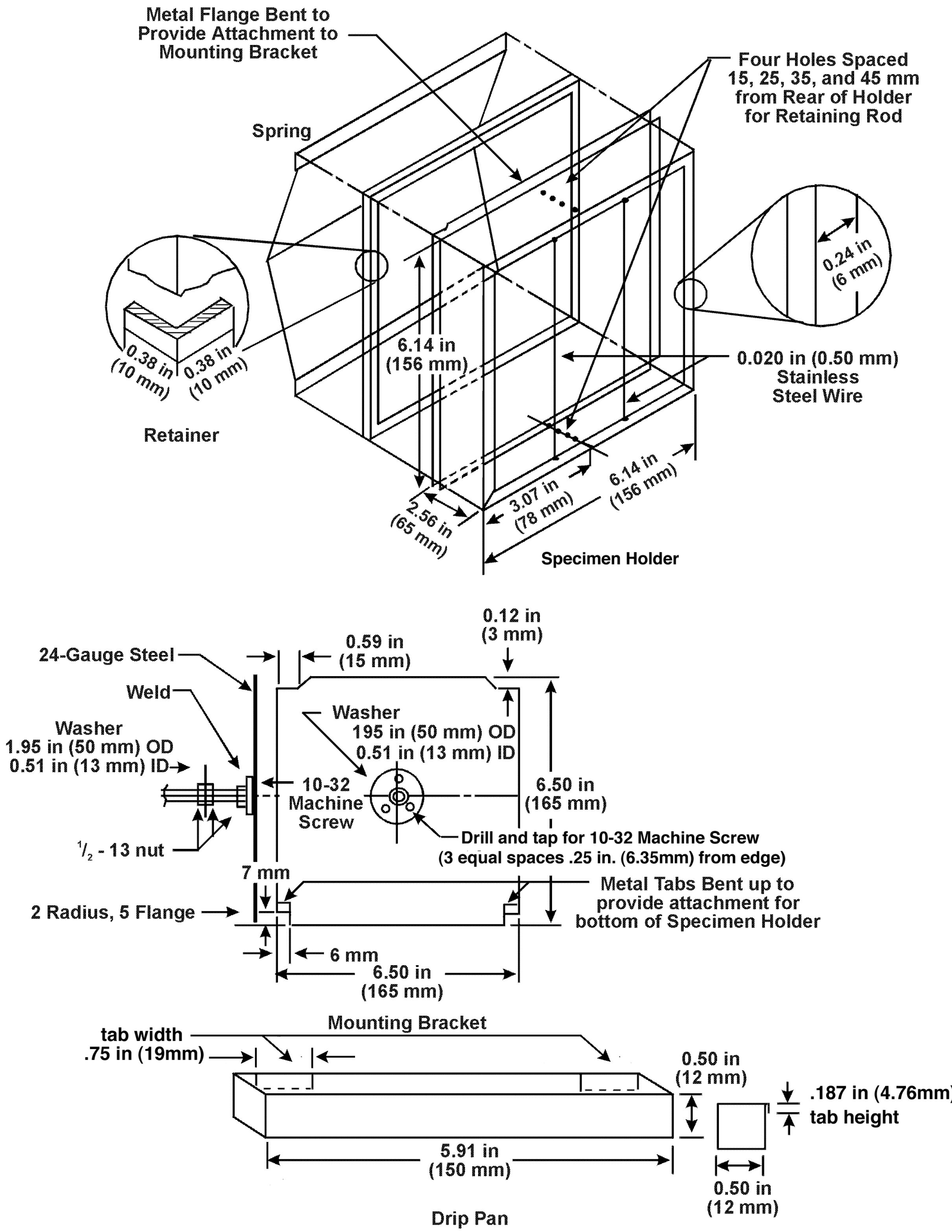

Figure 5-4. Heat Release Specimen Holder, Mounting Bracket, and Drip Pan

5.3.8 Pilot Burners

Pilot burners will be placed at locations near the bottom and top of the specimens (see figure 5-1a). The burners will be constructed of stainless steel tubing with a 0.25-inch (6.4-mm) outside diameter and 0.03-inch (0.8-mm) wall thickness.

5.3.8.1 Lower Pilot Burner

The lower pilot burner will be located as shown in figure 5-1a. The lower pilot burner will have its centerline perpendicular to the surface of the specimen and 0.19 inch (5 mm) above the specimen's lower exposed edge and will have its end 0.38 inch (10 mm) from the specimen surface. A methane-air mixture will be used, consisting of 0.004 ft^3/min (120 cm^3/min) (at standard temperature and pressure) methane (99 percent minimum purity) and an air supply adjusted to produce a flame such that the inner cone is approximately the same length as the diameter of the burner tube. (See figure 5.5.)

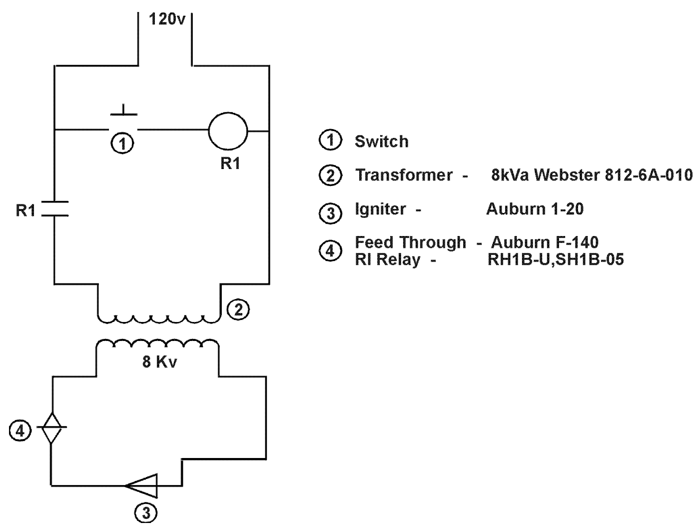

Figure 5-5. Lower Pilot Burner Igniter Schematic

5.3.8.2 Upper Pilot Burner

An upper pilot burner will be provided to produce 15 flamelets above the test specimen to ignite flammable gases (see figure 5-6). During the test, if there is any period of time longer than 3 seconds when any three or more of the flamelets on the upper pilot burner are not burning, the test is invalidated.

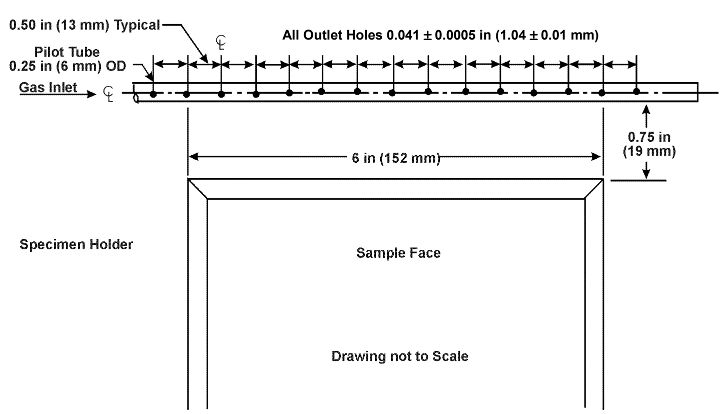

Figure 5-6. Upper Pilot Burner - 15 Hole Burner

5.3.8.2.1 The upper pilot burner will be constructed from a piece of stainless steel tubing with an outside diameter (OD) of 0.25 inch (6.3 mm) and a wall thickness of 0.03 inch (0.8 mm). Fifteen 0.041 ± 0.0005-inch (1.04 ± 0.01-mm) -diameter holes, each radiating in the same direction, will be drilled into a 15-inch (381-mm) length of tubing. The holes will be spaced 0.5 inch (13 mm) apart with the first hole located 0.5 inch (13 mm) from the closed end, as shown in figure 5-6. The tubing will be inserted into the environmental chamber through a 0.25-inch (6.3-mm) hole drilled to locate the tubing 0.79 inch (20 mm) above and 0.79 inch (20 mm) behind the upper front edge of the specimen holder and installed so that the holes are directed horizontally toward the radiant heat source. One end of the tubing will be closed with a silver solder plug or equivalent.

5.3.8.2.2 The burner will be positioned above the specimen holder so that the holes are placed above the specimen holder facing the heat source, as shown in figure 5-1a.

5.3.8.2.3 The fuel fed to this burner will be methane of 99 percent minimum purity mixed with air in a ratio of approximately 50/50 by volume. The total fuel flow will be adjusted to provide flamelets approximately 1 inch (25 mm) long. When the gas/air ratio and its fuel flow rate are properly adjusted, approximately 0.25 inch (6 mm) of the flame length appears yellow in color.

5.4 Test Specimens

5.4.1 Specimen Size

The standard size for specimens is 5.94 + 0, -0.06 by 5.94 + 0, -0.06 inches (150 + 0, -2 by 150 + 0, -2 mm) in lateral dimensions. Specimen thickness is as used in the relevant application up to 1.75 inches (45 mm); applications requiring thicknesses greater than 1.75 inches (45 mm) will be tested in 1.75-inch (45-mm) thicknesses.

5.4.2 Specimen Number

A minimum of three specimens will be prepared and tested for each material/part.

5.4.3 Specimen Mounting

Only one surface of a specimen will be exposed during a test. A single layer of 0.0012 ± 0.0005-inch (0.03 ± 0.01-mm) -thick aluminum foil will be wrapped tightly on all unexposed sides with the dull side of the foil facing the specimen surface. The foil must be continuous and not torn. The retaining frame will be placed behind the specimen between the back of the specimen and the pressure plate.

5.4.4 Specimen Orientation

For materials that may have anisotropic properties (i.e., different properties in different directions, such as machine and cross-machine directions for extrusions, warp and fill directions of woven fabrics, etc.), the specimens will be tested in the orientation thought to give the highest results. If the average maximum heat release rate exceeds 58 kW/m^2 or the average total heat released during the first 2 minutes exceeds 58 kW min/m^2, a second set of specimens will be prepared and tested in the orientation that is perpendicular to the orientation used for the first set of specimens. The higher value for the average maximum heat release rate and the higher value for the average total heat released during the first 2 minutes will be reported.

5.5 Conditioning

5.5.1 Specimens will be conditioned at 70 ± 5°F (21 ± 3°C) and 50% ± 5% relative humidity for a minimum of 24 hours prior to test.

5.6 Calibration

5.6.1 Calibration Burner

A calibration burner, as shown in figure 5-7, will be provided that fits over the end of the pilot flame tubing with a gas-tight connection. T-bar outlets will be approximately the same height as the lower pilot outlet.

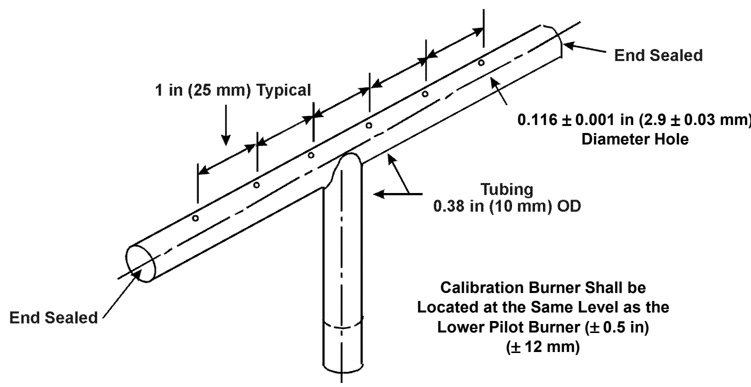

Figure 5-7. Typical Calibration Burner

5.6.2 Calibration Gas

Methane of at least 99 percent purity will be used for calibration purposes.

5.6.3 Wet Test Meter

A wet test meter accurate to 0.007 ft^3/min (0.2 L/min) will be provided to measure the gas flow rate to the calibration burner. Prior to usage, the wet test meter will be leveled and filled with distilled water to the tip of the internal pointer, according to manufacturer instructions.

5.6.4 Calibration Gas Manifold

5.6.4.1 A means will be provided upstream of the wet test meter to control calibration gas flow. The means will have flow orifices preset to provide calibration gas at approximate (uncorrected for the presence of water vapor) flow rates of 0.035, 0.14, 0.21, and 0.28 ft^3/min (1, 4, 6, and 8 L/min), as indicated by revolution rate (measured by a stop watch accurate to 1 second) of the wet test meter. Output from each of the flow orifices will be controlled by an on/off means and be plumbed into a single-flow line so that the calibration gas flow rate to the calibration burner can be set at 0.035, 0.14, 0.21, or 0.28 ft^3/min (1, 4, 6, and 8 L/min).

5.6.4.2 The actual, corrected value, F, of each of the flow rates will be determined to an accuracy of 0.007 ft^3/min (0.2 L/min), and these corrected values are used for calibration calculations in section 5.6.6.

5.6.5 Calibration Procedure

5.6.5.1 Replace the lower pilot burner with the calibration burner shown in figure 5-7.

5.6.5.2 Install the wet test meter. Ensure that it is leveled and filled with distilled water. Ambient temperature and water pressure are based on the internal wet test meter temperature.

5.6.5.3 Turn on the air distribution system.

5.6.5.4 Turn on the radiant heat source and ensure that the heat flux is 3.5 ± 0.05 W/cm^2.

5.6.5.5 Using the calibration gas manifold, set the baseline flow rate of 1 L/min of methane to the calibration burner and light the burner. Measure the thermopile baseline voltage.

5.6.5.6 Immediately prior to recording the thermopile outputs, as discussed in section 5.6.5.7, precondition the chamber at a methane flow rate of 8 L/min for 2 minutes. Do not record the thermopile output for this step as part of the calibration.

5.6.5.7 The gas flow to the burner is increased to a higher flow rate and then decreased to the baseline flow rate. After 2 minutes of burning at each rate, monitor the thermopile output (millivolts) for a 10-second period, record the average reading, and decrease the flow rate to the baseline flow of 1 L/min. This sequence of increasing and decreasing the methane flow rate is as follows: 0.035 - 0.14 - 0.035 - 0.21 - 0.035 - 0.28 - 0.035 - 0.21 - 0.035 - 0.14 ft^3/min (1 - 4 - 1 - 6 - 1 - 8 - 1 - 6 - 1 - 4 L/min).

5.6.6 Compute the calibration factor for each upward rate step (i.e., 1 - 4, 1 - 6, 1 - 8, 1 - 6, 1 - 4 L/min) according to the following formula:

$$k_h = 23.55 \times \frac{273}{T_a} \times \frac{(P_a - P_v)}{760} \times \frac{(F_1 - F_0)}{(V_1 - V_0)} kW/m^2 - mv$$

where:

F_1	=	Actual upper flow rate of calibration gas, in L/min (either 4, 6, or 8)
F_0	=	Actual baseline flow rate of methane, in L/min (approximately 1 L/min)
P_a	=	Ambient atmospheric pressure, in mm Hg
P_v	=	Water vapor pressure of wet test meter water temperature, in mm Hg
T_a	=	Ambient temperature, in °K
V_1	=	Thermopile voltage at upper flow rate, in *mv*
V_0	=	Thermopile voltage at baseline flow rate, in *mv*

5.6.7 Average the five results and compute the percent relative standard deviation. If the percent relative standard deviation is greater than 5 percent, repeat the determination. If it is less than 5 percent, use the average as the calibration factor.

5.7 Test Procedure

5.7.1 Set the airflow to the equipment by adjusting the pressure differential across the orifice plate to 7.87 inches (200 mm) of mercury.

5.7.2 Set the power supply to the Globars to produce a radiant flux density of 3.5 ± 0.05 W/cm^2 at the point that the center of the front surface of the specimen will occupy when positioned for test.

5.7.3 Light the pilot flames and check that their positions are as described in sections 5.3.8.1 and 5.3.8.2. Activate the spark igniter if a spark igniter is used.

5.7.4 If the test specimen consists of material that sags and/or drips to the extent that part of it may fall out of the holder during the test, attach the drip pan to the specimen holder, as described in section 5.3.6.1.

5.7.5 Place the specimen in the hold chamber with the radiation shield doors closed. Secure the airtight outer door and start the recording devices. Hold the specimen in the hold chamber for 60 ± 10 seconds.

5.7.6 Record, at least once a second, the thermopile millivolt output during the final 20 seconds of the hold time before the specimen is injected, and report the average as the baseline thermopile reading (millivolts).

5.7.7 After recording the baseline reading and within a timeframe not exceeding 3 seconds, open the radiation doors, inject the specimen into the burn chamber, and close the radiation doors. Record thermopile millivolt outputs at least once a second for the duration of the test.

5.7.8 After the test has run for 5 minutes, terminate the test and remove the sample.

5.7.9 Observe and note any extinguishment of pilot flames then discard data from any test during which the lower pilot burner was extinguished for any period of time exceeding 3 seconds or during which at least three of the upper pilot flamelets were extinguished simultaneously for any period of time exceeding 3 seconds.

5.7.10 Calculate the heat release rate for any point of time from the reading of the thermopile output voltage, V at that time as heat release rate = $k_h \times (V_1 - V_0)$, where k_h and V_0 are the calibration factor and thermopile millivolt reading at the baseline, respectively.

5.7.11 Determine and record the maximum heat release rate during the 5-minute test.

5.7.12 Compute and record the total heat released during the first 2 minutes of testing by integrating the heat release rate versus time curve during the first 2 minutes.

5.7.13 Clean the thermopile hot junctions to remove soot after testing each set of specimens.

5.8 Report

5.8.1 Fully identify the material tested, including thickness.

5.8.2 Determine and record the average maximum heat release rate during the 5-minute test, and the average total heat released during the first 2 minutes for all specimens tested (in worst-case direction).

5.8.3 Report the radiant heat flux to the specimen in W/cm^2 and data giving release rates of heat (in kW/m^2) as a function of time, either graphically or tabulated at intervals no greater than 10 seconds, and the calibration factor k_h.

5.8.4 Report any melting, sagging, delamination, or other behavior that affected the exposed surface area or mode of burning that occurred and the time(s) at which such behavior occurred.

5.9 Requirements

5.9.1 The average maximum heat release rate during the 5-minute tests will not exceed 65 kW/m^2.

5.9.2 The average total heat released during the first 2 minutes will not exceed 65 kW min/m^2.

NOTE: The 65/65 acceptance criteria above are the definitive requirements in FAR 25, Amendment 25-61 (FAR 25.853[a-1]), covering affected new design airplanes whose Type Certificate is applied for after August 20, 1986. These definitive requirements are referenced in FAR 121, Amendment 121-189, and are required for all affected airplanes manufactured after August 20, 1990. All affected airplanes manufactured after August 20, 1988, but prior to August 20, 1990, must meet interim requirements of 100 kW/m^2 for the average heat release rate and 100 kW min/m^2 for the average total heat released during the first 2 minutes.

Chapter 5 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

5.3.2 The upper thermocouples in the thermopile must remain in the same position as when the last calibration was completed. A template may be necessary to maintain this position. Caution must be taken while cleaning the thermocouple junctions not to move them.

5.3.3 A device should be provided to monitor the current of the heating elements (globars) during testing; additionally, this may be used to adjust the globar current during initial warm up, before final adjustment.

5.3.4 The air distribution system circular plate orifice should be no thicker than 0.125 inch. The inner edges of the holes must be sharp. The holes in the lower plate are #4 drill size. The holes in the upper manifold are #26 drill size. The holes in the intermediate plate used for air flow disbursement are #28 drill size.

5.3.5 The exhaust stack and area above the upper manifold should be cleaned periodically of soot deposits.

5.3.7 A second calorimeter should be used periodically to check the active calorimeter and its calibration should be first generation from National Institute of Standards and Technology (NIST) or the calorimeter manufacturer.

5.3.8 A method to provide reignition of the lower pilot flame is recommended. A spark ignitor should be installed to ensure that the lower pilot burner remains burning. A test is invalidated if the lower pilot burner becomes extinguished for any period that exceeds 3 seconds. A circuit for a satisfactory device is sketched in figure 5-5.

If an electric sparking device is used, an appropriate method of suppression and equipment shielding must be applied to have no interference with the ability of the data acquisition equipment to accurately record data.

5.3.8.2 The upper pilot holes are #59 drill size.

5.4.1 *to be added: reducing thickness of sample*

5.4.2 For test purposes, specimens should be marked with an arrow by manufacturers or operators for a consistent direction.

5.4.4 If there is evidence that a material does not demonstrate isotropic flammability characteristics and its heat release numbers in any one direction average greater than 58, either 2 minute or peak, the material must be tested in both directions. Examples of those types of materials that may not exhibit isotropic flammability characteristics are rugs and textiles.

5.6.1 The calibration T-bar burner holes are #32 drill size.

5.6.3 The tubing from the wet test meter to the calibration T-bar must be as short as possible and direct in routing. Also, the wet test meter must be last in line to the calibration T-bar.

5.7.6 Extreme caution must be used to ensure that the baseline reading is completed prior to opening inner doors for sample injection.

5.7.9 The use of an externally positioned mirror may assist in viewing upper pilot flames during testing.

5.7.13 A small, soft-bristled brush has been found satisfactory. Do not disturb the position of the thermocouples. Ensure that the thermocouples are in their proper position before proceeding with the next specimen; a template may be used to facilitate this step.